Numerical Solutions of Navier-Stokes Equations for Compressible Turbulent Two/Three Dimensional Flows in the Terminal Shock Region of an Inlet/Diffuser

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Summary

The multi-dimensional ensemble-averaged compressible time-dependent
Navier-Stokes equations in conjunction with mixing length turbulence model and
shock capturing technique have been used to study the terminal shock type of
flows in various flight regimes occurring in a diffuser/inlet model. The
numerical scheme for solving the governing equations is based on a linearized
block implicit approach and the following high Reynolds number calculations
have been carried out: (1) 2-D, steady, subsonic; (2) 2-D, steady, transonic
with normal shock, (3) 2-D, steady, supersonic with terminal shock, (4) 2-D,
transient process of shock development and (5) 3-D, steady, transonic with
normal shock. The numerical results obtained for the 2-D and 3-D transonic
shocked flows have been compared with corresponding experimental data; the
calculated wall static pressure distributions agree well with the measured
data.

INTRODUCTION

Proper design of the inlet flow region upstream of the compressor face is an important component in the overall design of the aircraft gas turbine for subsonic, transonic and supersonic inlet configurations.

In principle many of the problems of subsonic aircraft inlets are also encountered with transonic and supersonic installations. However, particular complexity is found in practice with transonic and supersonic aircraft, since not only is there the enlarged flight regime to consider, but now the influence of inlet shock structure on flow stability and engine-inlet matching must be taken into account. The importance and complexity of the influence of this inlet shock structure requires detailed investigation, which at present is accomplished by extensive and expensive experimental testing. Recently, however, there have been encouraging developments in the potential use of analyses to reduce the required extensive experimental mapping. In the transonic and supersonic inlet, the flow field can be divided into three main components: a supersonic region in the upstream portion of the inlet which leads into the terminal shock region and finally a subsonic diffusion region downstream of the terminal shock. In regard to the supersonic region Buggeln, McDonald, Levy and Kreskovsky (Ref. 1) have developed a three-dimensional spatial forward marching viscous flow analysis which has been applied successfully to several supersonic inlet configurations (Refs. 1-4). Although this analysis has given very favorable results in the supersonic portion of the inlet, the assumptions required to allow a forward marching calculation are inappropriate in the region of the terminal shock. Downstream of the terminal shock region, the flow is entirely subsonic and in this region the subsonic spatial forward marching analysis of Levy, Briley and McDonald (Ref. 5) is available. However, a portion of the flow field still requiring attention is the terminal shock region where procedures which are based upon a spatial forward marching method are invalid. It is this terminal shock region which is the subject of the present effort.

The terminal shock region is a very difficult problem which impacts upon both the loss characteristics and stability characteristics of the inlet flow. In a practical mixed compression supersonic inlet, the requirement of shock structure stability determines to large extent the normal shock loss in the inlet, itself a major contribution to the overall inlet losses. In essence by allowing some supersonic expansion after the geometric throat i.e. supercritical operation,

with subsequent shock down to subsonic flow via a normal shock, stability margin is obtained at the cost of the normal shock loss. If the normal shock were to occur very near the geometric throat where the local Mach number was unity, the resulting normal shock loss would be minimal but the inlet would be susceptable to unstarting. Having some supersonic reacceleration after the geometric throat places the normal shock downstream of the throat where a degree of stable upstream shock movement is possible without unstarting the inlet. This upstream shock movement could be unavoidable in practice for instance as the result of changing engine operating conditions or the result of changes in the external flow. Thus, an inlet design in which a terminal shock of some finite strength occurs downstream of the throat is a common occurrence.

The flow in the region of the terminal shock is very complex. First of all it is transonic, secondly shockwave boundary layer interaction with possible accompanying separation occurs and thirdly the flow is very sensitive to area changes, and hence to the three-dimensionality of the geometry. As a result of these properties optimizing the location of the normal shock to maximize stability while minimizing losses is a very demanding, yet very important task for analysis. Further, although the flow downstream of the normal shock may be treated by viscous subsonic forward schemes, nevertheless it has the transonic region as initial conditions, and the forward marching calculation may prove sensitive to the inflow and hence require an accurate definition of the initial conditions. Thus, there exists powerful motivation to develop an analysis of the transonic region of the inlet, which would include three-dimensionality and viscous effects. The ability to compute time-dependent flows would also be valuable. With this feature the steady flow (should it exist) would be computed as the time asymptote of the integration from the initial time zero guess of the flow field. Following this, the steady transonic shock structure could be perturbed and the stability of the system determined. The transient perturbation could be introduced by varying the inlet or the exit condition, depending on the physical disturbance being simulated.

Insofar as the governing equations are concerned, the inherent mixed elliptic hyperbolic nature of steady transonic flow does not encourage the use of forward marching in space, except perhaps in some corrector sense once an approximate transonic solution has been obtained. For governing equations one could consider the transonic potential equation, however, in the current problem a knowledge of the shock losses is critical, and this

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precludes a potential approach. Turning to the Euler equations, these
would permit shock losses to occur; however, the interest in and flow
sensitivity to the interaction with the wall boundary layers make a viscous
correction mandatory. The prospect of performing a numerical solution of the
Euler equations and coupling this in an iterative manner with a three-
dimensional boundary layer scheme at transonic speeds is not attractive.
Even if converged solutions could be obtained the resulting scheme would be
unlikely to offer any significant savings in computational expense relative
to solving the full Navier-Stokes equations, at least at transonic speeds
where the interaction between the core flow and the boundary layer could be
very sensitive and difficult to converge. In any event, the resulting
procedure would still suffer difficulties with flow separation. The complex
fluid mechanics involved in the transonic region of the inlet make the use of
the three-dimensional compressible ensemble-averaged time-dependent Navier-
Stokes equations attractive for this problem. Such an approach is described
in the present report.

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LIST OF SYMBOLS

A^+	van Driest damping coefficient
Cp	specific heat at constant pressure
D	determinant of the Jacobian matrix
$\mathbb{D}$	dissipation function
d	distance to the nearest wall
d^+	dimensionless distance to the nearest wall
h	enthalpy, throat height
ℓ	mixing length
ℓ_∞	mixing length in the core flow region
p	static pressure
q	magnitude of the velocity
$\vec{q}^T$	turbulent heat flux vector
$\bar{\vec{q}}$	mean heat flux vector
R	universal gas constant
R_e	Reynolds number
t	time
T	temperature
T°	stagnation temperature
$\vec{u}$	velocity vector

Symbols

u	velocity component in x-direction
u_τ	friction velocity
v	velocity component in y-direction
w	velocity component in z-direction
w_e	w at the edge of the boundary layer
x, x_1	cartesian coordinate in transverse direction
y, x_2	cartesian coordinate in spanwise direction
y^1, y^2, y^3	computational coordinates
z, x_3	cartesian coordinate in streamwise direction

Greek Symbols

δ	boundary layer thickness
ε	turbulence energy dissipation rate
κ	von Karman constant
μ	dynamic viscosity
ν_{art}	artificial dissipation
ξ, η, ζ	computational coordinates
$\overline{\overline{\pi}}$	molecular stress tensor
$\overline{\overline{\pi}}^T$	turbulent stress tensor

Greek Symbols

ρ	density
σ	artificial dissipation parameter
τ	time
τ_ℓ	local shear stress
τ_{xx}, τ_{xy}, etc.	component of stress tensor
Φ	meanflow dissipation rate

Subscripts

b	associated with the bottom wall
s	associated with the side wall
t	associated with the time or top wall
x	associated with the x-direction
y	associated with the y-direction
z	associated with the z-direction

Superscripts

T	associated with turbulent quantities, transpose of matrix

ANALYSIS

Governing Equations

The equations used in the present effort are the ensemble-averaged, time-dependent Navier-Stokes equations which can be written in vector form as

Continuity

$$\frac{\partial \rho}{\partial t} - \nabla \cdot \rho \vec{u} = 0 \tag{1}$$

Momentum

$$\frac{\partial \rho \vec{u}}{\partial t} + \nabla \cdot (\rho \vec{u}\,\vec{u}) = -\nabla p + \nabla \cdot (\bar{\bar{\pi}} + \pi^T) \tag{2}$$

Energy

$$\frac{\partial \rho h}{\partial t} + \nabla \cdot (\rho \vec{u} h) = -\nabla \cdot (\bar{\vec{q}} + \vec{q}^T) + \frac{\mathcal{D}p}{\mathcal{D}t} + \Phi + \rho \epsilon \tag{3}$$

where ρ is density, $\vec{u}$ is velocity, p is pressure, $\bar{\bar{\pi}}$ is the molecular stress tensor, π^T is the turbulent stress tensor, h is enthalpy, $\bar{\vec{q}}$ is the mean heat flux vector, $\vec{q}^T$ is the turbulent heat flux vector, Φ is the mean flow dissipation rate and ϵ is the turbulence energy dissipation rate. If the flow is assumed at a constant total temperature, the energy equation is replaced by

$$T^{\circ} = T + \frac{q^2}{2C_p} = constant \tag{4}$$

where T° is the stagnation temperature, q is the magnitude of the velocity and C_p is the specific heat at constant pressure. For the purpose of economy, both in terms of run time and computer storage, calculations presented in this report were run with the constant total temperature assumption. These equations, supplemented by an equation of state,

$$p = \rho R T \tag{5}$$

form the system governing the terminal shock region problem.

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Dependent Variables and Coordinate Transformation

The governing equations, Eqs. (1) - (3), are written in general vector form and prior to their application to specific problems it is necessary to decide upon both a set of dependent variables and a proper coordinate transformation. Based upon previous investigations (e.g. Refs. 6 and 7) the specific scalar momentum equations to be solved are the x, y and z Cartesian momentum equations. The dependent variables chosen are the physical Cartesian velocities u, v, w and the density ρ.

The equations are then transformed to a general coordinate system in which the general coordinates, y^j are related to the Cartesian coordinates, x_1, x_2 and x_3 by

$$y^j = y^j(x_1, x_2, x_3, t) \qquad ; \qquad j = 1, 2, 3.$$

$$\tau = t$$

(6)

As implied by Eq. (6), the general coordinate y^j may be a function of both the Cartesian coordinates <u>and</u> time. This coordinate time dependence will have an implication in so far as the choice of governing equation form is concerned.

The governing equations can be expressed in terms of the new independent variables y^j as

$$\frac{\partial W}{\partial \tau} + \xi_t \frac{\partial W}{\partial \xi} + \xi_x \frac{\partial F}{\partial \xi} + \xi_y \frac{\partial G}{\partial \xi} + \xi_z \frac{\partial H}{\partial \xi}$$

$$+ \eta_t \frac{\partial W}{\partial \eta} + \eta_x \frac{\partial F}{\partial \eta} + \eta_y \frac{\partial G}{\partial \eta} + \eta_z \frac{\partial H}{\partial \eta}$$

$$+ \zeta_t \frac{\partial W}{\partial \zeta} + \zeta_x \frac{\partial F}{\partial \zeta} + \zeta_y \frac{\partial G}{\partial \zeta} + \zeta_z \frac{\partial H}{\partial \zeta}$$

(7)

$$= \frac{1}{Re} \left[\xi_x \frac{\partial F_1}{\partial \xi} + \eta_x \frac{\partial F_1}{\partial \eta} + \zeta_x \frac{\partial F_1}{\partial \zeta} \right.$$

$$+ \xi_y \frac{\partial G_1}{\partial \xi} + \eta_y \frac{\partial G_1}{\partial \eta} + \zeta_y \frac{\partial G_1}{\partial \zeta}$$

$$\left. + \xi_z \frac{\partial H_1}{\partial \xi} + \eta_z \frac{\partial H_1}{\partial \eta} + \zeta_z \frac{\partial H_1}{\partial \zeta} \right]$$

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through a straight forward application of chain rule differentiation. In Eq. (7)

$$\xi = y^1$$

$$\eta = y^2$$

$$\zeta = y^3$$

and

$$W = \begin{bmatrix} \rho \\ \rho u \\ \rho v \\ \rho w \end{bmatrix} \quad , \quad F = \begin{bmatrix} \rho u \\ \rho u^2 + p \\ \rho u v \\ \rho u w \end{bmatrix} \quad , \quad G = \begin{bmatrix} \rho v \\ \rho u v \\ \rho v^2 + p \\ \rho v w \end{bmatrix}$$

$$(8)$$

$$H = \begin{bmatrix} \rho w \\ \rho u w \\ \rho v w \\ \rho w^2 + p \end{bmatrix} \quad , \quad F_1 = \begin{bmatrix} 0 \\ \tau_{xx} \\ \tau_{xy} \\ \tau_{xz} \end{bmatrix} \quad , \quad G_1 = \begin{bmatrix} 0 \\ \tau_{xy} \\ \tau_{yy} \\ \tau_{yz} \end{bmatrix} \quad , \quad H_1 = \begin{bmatrix} 0 \\ \tau_{xz} \\ \tau_{yz} \\ \tau_{zz} \end{bmatrix}$$

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Since in general the computational coordinates may be a function of time with a time-dependent Jacobian, the equations are recast into the so-called 'strong conservation form' (Ref. 8).

$$\frac{\partial W/D}{\partial \tau} + \frac{\partial}{\partial \xi}\left[\frac{W\xi_t}{D} + \frac{F\xi_x}{D} + \frac{G\xi_y}{D} + \frac{H\xi_z}{D}\right]$$

$$+ \frac{\partial}{\partial \eta}\left[\frac{W\eta_t}{D} + \frac{F\eta_x}{D} + \frac{G\eta_y}{D} + \frac{H\eta_z}{D}\right]$$

$$+ \frac{\partial}{\partial \zeta}\left[\frac{W\zeta_t}{D} + \frac{F\zeta_x}{D} + \frac{G\zeta_y}{D} + \frac{H\zeta_z}{D}\right]$$

$$= \frac{1}{Re}\left[\frac{\partial}{\partial \xi}\left(\frac{F_l\,\xi_x}{D} + \frac{G_l\,\xi_y}{D} + \frac{H_l\,\xi_z}{D}\right) + \frac{\partial}{\partial \eta}\left(\frac{F_l\,\eta_x}{D} + \frac{G_l\,\eta_y}{D} + \frac{H_l\,\eta_z}{D}\right)\right.$$

$$\left. + \frac{\partial}{\partial \zeta}\left(\frac{F_l\,\zeta_x}{D} + \frac{G_l\,\zeta_y}{D} + \frac{H_l\,\zeta_z}{D}\right)\right]$$

(9)

where

$$D = \begin{vmatrix} \xi_x & \xi_y & \xi_z \\ \eta_x & \eta_y & \eta_z \\ \zeta_x & \zeta_y & \zeta_z \end{vmatrix}$$

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Equation (9) represents the Navier-Stokes equation in strong conservation form and represents the set of equations solved in the present work.

Insofar as the coordinate system is concerned, the cases considered in the present effort used a simplified coordinate transformation in which;

$$\xi = f_1(x,z)$$
$$\eta = f_2(y)$$
$$\zeta = f_3(z) \tag{10}$$

i.e., a stretched and contour-fitted non-orthogonal grid was used. The specific grid transformation used in the streamwise direction is that of Oh (Ref. 9), which allows high resolution in user specified regions. In the cross-sectional plane hyperbolic tangent transformations were adopted. The regions of high resolution were taken to be those near solid walls (in the x and y directions) and those near the throat as well as region of sharp contraction of the contour in the z direction.

Turbulence Model

Since the flows of interest are in the turbulent regime, it is necessary to specify a turbulence model. The present results were obtained from the McDonald's model (Ref. 10) with Van Driest damping (Ref. 11),

$$\ell = \ell_\infty \tanh\left[\frac{\kappa d}{\ell_\infty}\right]\left[1 - \exp\left(-\frac{d^+}{A^+}\right)\right] \tag{11}$$

where κ is the von Karman constant, A^+ is the van Driest damping coefficient and d is the distance to the nearest solid wall.

$$\ell_\infty = 0.09\delta \qquad , \qquad A^+ = 26.0$$

and $\kappa = 0.40$ for two-dimensional calculations, while $\kappa = 0.41$ for three-dimensional calculations. The nondimensional distance d^+ is defined as

$$d^+ = d\left(\frac{\rho u_\tau}{\mu}\right) \tag{12}$$

and the friction velocity u_τ in the present analysis is taken as

$$u_\tau = \left(\frac{\tau_\ell}{\rho}\right)^{1/2} \tag{13}$$

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where the local shear stress τ_ℓ is obtained from

$$\tau_\ell = (2\mathbb{D}:\mathbb{D})^{1/2} \tag{14}$$

where $\mathbb{D}$ is the dissipation function

$$\mathbb{D} \equiv \frac{1}{2}\left[(\nabla\vec{U}) + (\nabla\vec{U})^T\right] \tag{15}$$

Note that for small d the tanh function in Eq. (11) reduces to κd while for large d it approaches ℓ_∞.

In boundary layer analysis ℓ_∞ is usually taken as 0.09δ where δ is the boundary layer thickness taken at the location where $w/w_e = 0.99$. However, this definition of δ assumes the existence of an outer flow where the velocity w_e is independent of distance from the wall at a given streamwise station, i.e., it assumes w_e is only a function of the streamwise coordinate. Most Navier-Stokes calculations show no such definitive region to exist and, therefore, an alternate definition is required. In the present effort the boundary layer thickness in the two-dimensional region was set by first determining w_{max}, the maximum streamwise velocity, at a given station and then setting δ via;

$$\delta = 2.0 d_{(w/w_{max} = k)} \tag{16}$$

i.e., δ was taken as twice the distance (measured away from the nearest wall) for which $w/w_{max} = k$. The value of k used in the present effort was 0.90. The mixing length in the core region was set by linear interpolation between the top and bottom wall boundary layer edge values. The model described above was used in two-dimensional calculations as well as in the nominally two-dimensional region of three-dimensional calculation. This nominally two-dimensional region was defined as $y \geq y_s \approx \delta_s$, where δ_s was the side wall boundary layer thickness evaluated, according to Eq. (16), at the midpoint between the top and bottom corners, and was taken as a measure of the overall boundary layer thickness along the side wall. Once δ_s had been determined, y_s was then set as the nearest y-location of the grid points with y_s being slightly larger than δ_s. Henceforth, the mixing lengths at each point along $y = y_s$,

together with the locations of the top and bottom wall boundary layer edges, were obtained as described before. A schematic of the cross-sectional regions involved in the three-dimensional calculation is depicted in Fig. A, in which x_b and x_t are the edges of the bottom and top wall boundary layers at $y = y_s$. In the bottom wall corner region (i.e., $0 \leq y^* < y_s$ and $0 \leq x^* < x_b$), the mixing lengths were calculated according to Eq. (11) with a constant ℓ_∞ specified as the length scale at the point (x_b, y_s). Similarly, the length scales of points in the top wall corner region (i.e., $0 \leq y^* < y_s$ and $x_t < x^* \leq x_{max}$) were evaluated according to Eq. (11) with another constant ℓ_∞ specified as the mixing length at the point (x_t, y_s). Finally, the length scales of points in the side wall boundary layer region (i.e. $0 \leq y^* < y_s$, $x_b \leq x^* \leq x_t$) were obtained by using Eq. (11) with ℓ_∞ specified as the respective mixing lengths at the points (x^*, y_s).
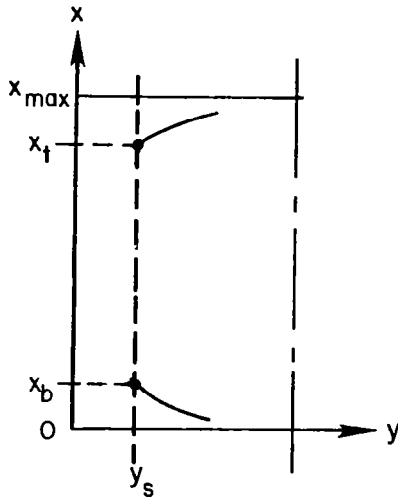
$y \geq y_s$: nominally 2-D region

$0 \leq y^* < y_s$, $x_b \leq x^* \leq x_t$: side wall B. L. region

$0 \leq y^* < y_s$, $0 \leq x^* < x_b$: bottom corner region

$0 \leq y^* < y_s$, $x_t < x^* \leq x_{max}$: top corner region

Figure A

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Boundary Conditions

The authors' experience in solving Navier-Stokes equations has indicated the important role of boundary conditions in determining accurate solutions and rapid numerical convergence. The boundary conditions used in the present calculations with subsonic inflow and outflow follow the suggestion of Briley and McDonald [12] which specifies upstream total pressure and downstream static pressure conditions. Following this approach the stagnation pressure, transverse velocity and pressure derivative were set on the upstream boundary. In addition, a boundary layer thickness was specified and a dimensionless boundary layer profile set in that region. No-slip conditions in conjunction with zero pressure gradient were set at solid walls. The static pressure and velocity second derivatives were set at the downstream boundary. As mentioned above, this approach is valid for subsonic inflow. If the flow at the upstream boundary is supersonic, then, instead of the total core flow conditions, values of velocity components and density must be specified [27]. A more detailed description of the boundary conditions used for the present calculations will be given later in the section "Test Cases".

Numerical Procedure

The numerical procedure used to solve the governing equations is a consistently split linearized block implicit (LBI) scheme originally developed by Briley and McDonald [13]. A conceptually similar scheme has been developed for two-dimensional MHD problems by Lindemuth and Killeen [14]. More recently Beam and Warming (Ref. 25) have derived this and other related schemes by the method of approximate factorization. The procedure is discussed in detail in Refs. 13 and 15. The method can be briefly outlined as follows: the governing equations are replaced by an implicit time difference approximation, optionally a backward difference or Crank-Nicolson scheme. Terms involving nonlinearities at the implicit time level are linearized by Taylor expansion in time about the solution at the known time level, and spatial difference approximations are introduced. The result is a system of multidimensional coupled (but linear) difference equations for the dependent variables at the unknown or implicit time level. To solve these difference equations, the Douglas-Gunn [16] procedure for generating alternating-direction implicit

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(ADI) schemes as perturbations of fundamental implicit difference schemes is introduced in its natural extension to systems of partial differential equations. This technique leads to systems of coupled linear difference equations having narrow block-banded matrix structures which can be solved efficiently by standard block-elimination methods.

The method centers around the use of a formal linearization technique adapted for the integration of initial-value problems. The linearization technique, which requires an implicit solution procedure, permits the solution of coupled nonlinear equations in one space dimension (to the requisite degree of accuracy) by a one-step noniterative scheme. Since no iteration is required to compute the solution for a single time step, and since only moderate effort is required for solution of the implicit difference equations, the method is computationally efficient; this efficiency is retained for multidimensional problems by using what might be termed block ADI techniques. The method is also economical in terms of computer storage, in its present form requiring only two time-levels of storage for each dependent variable. Furthermore, the block ADI technique reduces multidimensional problems to sequences of calculations which are one dimensional in the sense that easily-solved narrow block-banded matrices associated with one-dimensional rows of grid points are produced. A more detailed discussion of the solution procedure as discussed by Briley, Buggeln and McDonald [17] is given in the Appendix.

Artificial Dissipation

One major problem to be overcome in calculating high Reynolds number flows using the Navier-Stokes equations is the appearance of spatial oscillations associated with the so-called central difference problem. When spatial derivatives are represented by central differences, high Reynolds number flows can exhibit a saw tooth type oscillation unless some mechanism is added to the equations to suppress their appearance. This dissipation mechanism can be added implicitly to the equations via the spatial difference molecule (e.g. one-sided differencing) or explicitly through addition of a specific term. The present authors favor this latter approach for two reasons. First, if a specific artificial dissipation term is added to the equations, it is clear precisely what approximation is being made. Secondly, if a specific term is added to suppress oscillations, the amount of artificial dissipation added to the equations can be easily controlled in magnitude and location so as to add the minimum amount necessary to suppress spatial

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oscillations. Studies can also be easily performed to evaluate the effect of the explicitly added dissipation on the solution.

Various methods of adding artificial dissipation were investigated in Ref. 18, and these were evaluated in the context of a one-dimensional model problem. The model problem used was one-dimensional flow with heat transfer. Flow was subsonic at the upstream boundary, accelerated via heat sources until a Mach number of unity was reached and then accelerated by heat sinks. The exit back pressure was raised to cause a shock to appear in the supersonic region. This basic one-dimensional problem contained many relevant features including strong accelerations and appearance of a normal shock wave and, therefore, it served as a good test case for various forms of artificial dissipation which could be used in the presence of shock waves.

The results of the Ref. 18 investigation led to the conclusion that for the model problem a second order artificial dissipation approach was the best of those considered. This approach adds a term of the form $\nu_{art} \dfrac{\partial^2 \phi}{\partial z^2}$ or

$\dfrac{\partial}{\partial Z}\left\{\nu_{art} \dfrac{\partial \phi}{\partial Z}\right\}$ to each governing equation where $\phi = \rho$, u, v, w for the continuity, x-momentum, y-momentum and z-momentum equations respectively and ν_{art} is determined by $\dfrac{|U_Z| \Delta Z}{\nu + (\nu_{art})_Z} \leq \dfrac{1}{\sigma_Z}$

In the above equation ΔZ is the distance between grid points in a given coordinate direction, U_Z is the velocity in this direction, σ_Z is the artificial dissipation parameter for this direction and ν is the effective kinematic viscosity. The equation determines ν_{art} with ν_{art} taken as the smallest non-negative value which will satisfy the expression. It should be noted that in two space dimensions each equation contains two artificial dissipation terms, one in each coordinate direction. For example, the streamwise momentum equation expressed in two-dimensional Cartesian coordinates would contain the artificial dissipation terms

$$(\nu_{art})_x \dfrac{\partial^2 w}{\partial x^2} + (\nu_{art})_z \dfrac{\partial^2 w}{\partial z^2}$$

Obviously the desirable condition occurs when sufficient artificial dissipation is added to the equations to suppress spurious oscillations but the amount added does not perceptively change the physical solution. The results of Refs. 18 and 19 indicated that such conditions could be met when the dissipation parameter, σ, was varied between values of .10 and .025 and these results were confirmed for the terminal shock problem in the present effort.

Although the original artificial dissipation study was carried out with terms of the form $(\nu_{art})_z \, \partial^2\phi/\partial Z^2$, the form used in the present case was $\partial \, (\nu_{art} \, \partial\phi/\partial Z)/\partial Z$. However, recent studies for airfoil and cascade calculations indicate that for low values of σ little significant difference occurs as a result of using one form or the other.

Test Cases

Several test cases were run with the MINT computer code to evaluate the previously described computational procedures for inlet terminal shock flow problems. In general, works aimed at clarifying the fluid mechanical processes involved in the terminal shock region of channel flows are scarce and, in particular, the available data in many cases are not sufficiently complete to form the basis for detailed numerical comparisons. One experimental investigation which gives detailed measurements is that of Bogar, Sajben, Kroutil and Salmon (Refs. 20 and 21) which focuses upon flows in the terminal shock region of inlets/diffusers. More specifically, they investigated transonic flows in nominally two-dimensional, supercritically operated diffusers. These flows exhibit many significant features found in supersonic inlets of aircraft. A detailed description of the diffuser model and results describing both the time-mean and the oscillating flow properties were reported in Ref. 20, while laser Doppler velocimeter measurements were given in Ref. 21. Since these detailed data are considered as reliable and the trends observed are believed to be present in three-dimensional inlet flows as well, this particular data base was selected for designing the test cases for the present effort. The following five cases of different flows have been calculated: (1) two-dimensional subsonic diffuser flow, (2) two-dimensional transonic diffuser flow with a normal shock, (3) two-dimensional supersonic inlet flow with a terminal shock, (4) transient development of normal shock in a two-dimensional convergent-divergent channel and (5) three-dimensional transonic diffuser flow with a normal shock. In all of these calculations the flows are turbulent and, except for case (3), only the asymptotic steady-state solutions are of interest. Furthermore, the selected diffuser/inlet models are either geometrically similar or identical to each other.

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A schematic of the inlet/diffuser geometry and the associated coordinate system is shown in Fig. 1. The diffuser/inlet model is a convergent-divergent channel with a flat bottom and a contoured top wall. In addition, the cross-section is rectangular everywhere. A detailed description of this model can be found in Ref. 20 and will not be repeated here. However, it should be noted that the computational domain extends from 3.75h upstream of the geometric throat to 8.65h downstream of the throat, where h is the throat height. For the three-dimensional calculation, the throat cross-sectional aspect ratio is 3.0 with the computational domain extending from one side wall to the center plane, and no-slip conditions are applied on all solid walls. This is somewhat different from the experimental conditions in which the throat cross-sectional aspect ratio is 4.0 and suction slots are used at several locations to establish the nominal two-dimensionality of the flow.

An important aspect of almost all numerical calculations is the generation of a suitable computational coordinate system. The present approach uses a contour fitted coordinate system in which both top and bottom as well as side channel walls (for the three-dimensional calculation) fall on coordinate lines. As mentioned earlier, high grid resolution near the walls is obtained by employing a hyperbolic tangent grid packing transformation; the streamwise resolution is obtained by clustering grid points near the location of sharp contraction of the contour as well as near the expected location of the shock. This grid is accomplished by using a versatile grid distribution generator which allows multiple regions of grid packing (Ref. 9). For the present calculations, 31 grid points are used in the transverse direction (x-direction) while 41 grid points are used in the streamwise direction (z-direction). In addition, for three-dimensional case, 16 grid points are used in the spanwise direction (y-direction). Results of all the five test cases were obtained with the same grid distributions.

For all of the test calculations, the Reynolds number based on the inlet core flow condition and the throat height is approximately 4.73×10^5, the inlet core Mach number is approximately 0.46 for cases (1), (2), (4) and (5) while it is approximately 1.90 for case (3). Under the assumption that the flows are at constant total temperature, the equations solved are the continuity equation and momentum equations. The previously described mixing length model

and shock capturing technique are used to provide turbulent viscosity and to locate the shock. As for the boundary conditions, no-slip condition together with zero first derivative of the static pressure (with respect to the transverse computational coordinate) are imposed along the top and bottom walls. For three-dimensional case, no-slip condition together with zero first derivative of the static pressure (with respect to the spanwise computational coordinate) are applied along the side wall while the symmetry conditions are used for the center plane. At the exit where the flows are subsonic for all test cases, constant static pressure is specified and the second streamwise (computational coordinate) derivatives of all velocity components are set to be zero. For cases (1), (2), (4) and (5) the flows at the inlet are subsonic, the core flow total conditions together with wall boundary layer thicknesses and profile shapes of the streamwise velocity component are specified. In addition, the second streamwise (computational coordinate) derivatives of static pressure and velocity components in the cross-sectional plane are set to be zero. Experience indicates that it may be beneficial to freeze the cross-sectional velocity components after the initial impulsive transients had passed and this is done for case (5) to obtain the highly damped solution. As for the profile of the streamwise velocity component, the profile suggested by Musker (Ref. 22) supplemented by the Van Driest transformation (Ref. 23) to account for the effects of compressibility is adopted. In case (3), the flow at the inlet section is supersonic except in wall regions of the boundary layer, the velocity components, the density and the static enthalpy (temperature) are specified for the supersonic portion while the second streamwise (computational coordinate) derivatives of the velocity components and the pressure are set to be zero for the subsonic portion of the inflow section. Consequently, the density and temperature in the subsonic portion are calculated in accordance with the specified total enthalpy (temperature) and the equation of state. In this way, the disturbances occurring in the subsonic portions of the internal flow field are allowed to propagate through the upstream inflow section.

Since the governing equations are time-dependent, initial conditions are needed to start the calculation. In general, a relatively simple approximation to the flow field suffices as an initial condition, however, if a better estimate is easily available it should be used. The construction of the initial

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conditions for each test case will be described in the following section.
However, a general comment concerning the presence of the discontinuities in the
initial conditions should be made here, since it is relevant to the terminal shock
type of calculations. One of the most important reasons for the occurrence of
surfaces of discontinuity in a gas is the possibility of discontinuities in the
initial conditions. These conditions may in general be prescribed arbitrarily.
It is known, however, that certain conditions must hold on stable surfaces of
discontinuity in a gas; for instance, the discontinuities of pressure, density,
etc. in a shock wave are related by the Rankine-Hugoniot relations. It is,
therefore, clear that if these conditions are not satisfied in the initial dis-
continuity, it cannot continue to be a discontinuity at subsequent instants.
Instead, it generally splits into several discontinuities (e.g. shock wave,
tangential discontinuity and rarefaction wave); in the course of time, these dis-
continuities of different types move apart. Their propagation, reflection and
subsequent interations may cause undesirable transient impulsives with the
possible consequences of prolonged computing time or even the instability of the
calculation. Therefore, special attention should be paid to the construction of
the initial condition for the terminal shock type of problems.

Computed Results

The previously described test cases cover various flow regimes occurring
in a diffuser/inlet model. Depending on the specified upstream and downstream
boundary conditions, the resultant internal flow field can be quite different
in nature. In most of these cases, asymptotic steady-state solutions are of
interest, however, physically meaningful transient solutions for the formation
of shock waves have also been obtained. In addition, the effects of artificial
dissipation on the numerical solutions have been studied and a three-dimensional
calculation has been carried out. A vast amount of information is obtained from
the computation of these test cases, and only selected, representative results
are to be presented here. The relevant flow parameters describing these cases
are given in Table I. These calculations were considered to reach an asymptotic
steady-state when there was virtually no change in the wall static pressure

distributions over a (dimensionless) time interval of 2 to 6, where a dimensionless time of 12 is the time required for a particle moving at the inlet velocity to pass from inlet to exit, and the changes in other flow variables were of very minor significance. In addition, the maximum residual decreased by one to two orders of magnitude, depending upon the initial conditions and the flow problems.

TABLE I – Parameters for Test Cases

Case	Type	Re_h	Inlet Core Mach No.	Inlet Top Wall Boundary Layer Thickness δ/h	Inlet Bottom Wall Boundary Layer Thickness δ/h	Inlet Side Wall Boundary Layer Thickness δ/h
1	2-D, Steady Subsonic	4.73×10^5	0.46	0.12149	0.060745	/
2	2-D, Steady Transonic with Shock	4.73×10^5	0.46	0.12149	0.060745	/
3	2-D, Steady Supersonic with Terminal Shock	4.73×10^5	1.90	0.12149	0.060745	/
4	2-D, Transient Formation of a Normal Shock	4.73×10^5	0.46	0.12149	0.060745	/
5	3-D, Steady Transonic with Normal Shock	4.73×10^5	0.46	0.12149	0.060745	0.060745

Case (1):   Steady 2-D Subsonic Diffuser Flow

The calculation was initiated with an initial condition which consisted of a one-dimensional inviscid flow corresponding to the specified diffuser contour with a simple boundary layer correction applied in the vicinity of no-slip surfaces. With this initial condition, it took about 60 time steps to reach an asymptotic steady state solution for $\sigma_x = \sigma_z = \sigma = 0.5$ (which corresponds to a cell Reynolds number of 2). At this stage, the artificial dissipation parameters were then lowered to $\sigma = 0.05$ (which corresponds to a cell Reynolds number 20), and it took about another 50 time steps to reach an asymptotic steady state wherein no observable changes occurred over a wide variation in time steps. The calculated top wall pressure distribution is depicted in Fig. 2, while the calculated bottom wall pressure distribution is shown in Fig. 3. For the purpose of reference, some relevant measured data for shocked flow, which is established by a lower exit pressure ($P_e = 0.933$ as compared to the present 0.96), are also given. It is obvious that the choice of the artificial dissipation parameters significantly affect the computed results. Previous experience at SRA with second order artificial dissipation calculations for transonic shock waves has indicated that accurate results and sharp shock representation can be obtained when σ is limited to 0.05. Although experimental data for this case is not available, the results shown in Figs. 2 and 3 are physically realistic. The wall pressures follow the data for a lower back pressure until slightly upstream of the throat as is expected. Since the calculation and the data are for cases with different back pressures, the results diverge as the throat is approached.

Case (2):   Steady 2-D Transonic Diffuser Flow with a Normal Shock

The solutions obtained with exit pressure $P_e = 0.96$ and the artificial dissipation $\sigma = 0.5$ was used as the initial condition for this calculation. At first, the back pressure was dropped to 0.933 over a short period of time and then fixed for the subsequent computations. After approximately 40 time steps an asymptotic steady state solution for $P_e = 0.933$ and $\sigma = 0.5$ was obtained. Then the artificial dissipation parameter σ was dropped to 0.05 and after another 40 time steps, the final steady-state solution for $P_e = 0.933$ and $\sigma = 0.05$ was reached. The calculated top wall pressure distribution is given in Fig. 4 and the calculated bottom wall pressure distribution is shown in Fig. 5. The calculated results for $\sigma = 0.05$ agree very well with the corresponding experimentally measured data (case denoted by $M_{\sigma u} = 1.235$ in

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Ref. 20). Again, the artificial dissipation parameter plays an important role, the shock is captured with $\sigma = 0.05$ while the results are severely smeared with $\sigma = 0.5$. In fact, the $\sigma = 0.5$ calculation does not even contain a supersonic region (Fig. 6). Further investigation of the sensitivity of the calculated flow fields with respect to the choice of the artificial damping parameter σ has been carried out for $\sigma = 0.1$. The calculated wall static pressure distributions for this value of σ are essentially the same as those for $\sigma = 0.05$ and are not presented here. Therefore, it may be concluded that the present numerical results are insensitive to the choice of the parameter σ when σ is in the range from 0.1 to 0.05. It is noted that, based upon previous experience for shocked flow, if no artificial dissipation were used the calculation would be unstable. However, as indicated by the present calculations, if too much artificial dissipation is used the solution would be unrealistically contaminated by its presence.

Case (3): Steady 2-D Supersonic Inlet Flow with Terminal Shock

The construction of the initial condition for this case was essentially the same as that for Case (1) except that, by applying the Rankine-Hugoniot relations, an initial discontinuity of the pseudo two-dimensional flow field was generated in the vicinity and downstream of the geometrical throat. The pressure boundary condition at the exit was specified with its ratio to the pressure at the inflow section being 5.70; this value is consistent with the initially assumed shock wave. Such a back pressure was held fixed for subsequent calculations. The calculation required 70 time steps to reach an asymptotic steady-state solution for $\sigma = 0.5$, and then, after lowering the artificial dissipation parameter to 0.1, another additional 50 time steps was needed to reach the final asymptotic steady state solutions where no further observable changes in the solution occurred. In Fig. 7 a schematic flow field is depicted; the difference in the streamwise and normal scales used in this figure should be noted. An oblique shock is formed in the region of the compression corner of the top wall (ramp) while near the bottom wall (cowl) a Mach reflection occurs and the terminal shock stands at approximately one throat height downstream of the geometric throat. The existence of the Mach reflection is consistent with the prediction due to the inviscid theory by noting that the core flow Mach Number near the inflow section is about 1.90 and the deflection angle of the top wall is about $18°$, under such conditions a regular reflection of the incident shock wave is not possible. Instead, a Mach reflection

must occur. At the compression corner there exists a separation region induced by the adverse pressure gradients near the wall. A relatively large shock-induced separation zone exists in the Mach reflection region. Further, there are terminal shock-induced separation regions along the top and bottom walls, although the one along the bottom wall is very thin. In Fig. 8 the corresponding dimensionless static pressure distribution along the top wall is presented and in Fig 9 the corresponding dimensionless static pressure distribution along the bottom wall is shown. No experimental data are available for comparison, nevertheless, these results are qualitatively in agreement with the known features of the supersonic inlet flow. The above calculations demonstrate the capability of the MINT code to compute turbulent flows in various flight regimes, as shown by the Mach Number contours depicted in Figs. 10a, b and c. In these figures, the main flow direction is from left to right. For Fig. 10a and Fig. 10b, the minimum contour value is 0.432 with constant increment of 0.032, while for Fig. 10c, the minimum contour value is 0.46 with constant increment of 0.06, the displayed domain extends from the inflow section to 3.4 h downstream of the throat where h is the throat height. Figure 10a shows the Mach Number contours of a subsonic diffuser flow, Fig. 10b illustrates that of a supercritically operated transonic diffuser flow with a normal shock region and Fig. 10c gives the Mach Number contours of a supersonic inlet in which the existence of the oblique shock waves, Mach leg and a terminal shock region is evident. The corresponding static pressure contours are given in Figs. 11a, b and c.

Case (4):   Unsteady Shock Development in a 2-D Transonic Diffuser

An investigation of the formation of the normal shock by lowering the back pressure (P_e) from that of a subsonic diffuser flow to that of a supercritically operated transonic diffuser flow also has been performed. The calculation started with the steady-state solution of the subsonic flow (P_e = 0.96 and σ = 0.05) and over a very short period of time the back pressure was dropped to 0.933 which was then held as constant. Small artificial dissipation parameter (σ = 0.05) and (constant) small dimensionless time step (Δt = 0.05) were used. Figure 12 shows the transient development of the static pressure along the top wall and Fig 13 shows the transient development of the static pressure along the bottom wall. As it can be seen, the final asymptotic steady-state solutions agree very well with the corresponding experimentally measured data (case denoted by $M_{\sigma u}$ = 1.235 in Ref. 20). Although a dimensionless

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time interval of 18 units was required for the flow to change from one steady-state (subsonic mode without shock) to another steady-state (transonic mode with a normal shock), the corresponding physical time interval is only about 0.53×10^{-2} second. Since its response to the changes of the back pressure are very rapid for this transient flow, very little information about the fluid mechanical process involved in the formation of shock has been provided by most of the relevant experiments for this problem. Some basic features of such a process are revealed by the present numerical investigation and will be presented here. The transient as well as spatial developments of the flow field are illustrated by Fig. 14, which is a history of Mach Number contours in a region which extends from two throat height upstream of the throat to 6 throat heights downstream of the throat. The minimum contour level is 0.432 with a constant increment of 0.032. The corresponding time history of static pressure contours are given in Fig. 15. In the early stages of the development, the disturbances originating at the outflow section propagate in the direction of the upstream; in particular, the propagating speed of the disturbances within the (contoured) top wall boundary layer is relatively large. Once these faster moving disturbances reach the throat region, disturbances transverse to the mean flow are generated, which then continue to propagate up-and downstream as they approach the (flat) bottom wall. In the later stages of shock development, disturbances propagating in upstream, downstream and transverse directions are undoubtedly present and they can interact with each other, but the most important disturbances responsible for the formation of the shock are the transverse waves originating at the boundary layer/core-flow interface, which are strongly influenced by the viscous-inviscid interactions.

Although the present calculation focuses upon the formation of the shock due to the small changes of the back pressure, the results obtained do strongly suggest that a one-dimensional inviscid approach is not appropriate for analyzing the response of the terminal shock in a supersonic inlet to the back pressure disturbances (i.e. the hammer shock problem). Such an indication is further supported by the results obtained from a relevant experimental work (Ref. 24) in which the shock motion induced by externally applied disturbances were investigated for a supercritically operated transonic diffuser.

Case (5): Steady 3-D Transonic Diffuser Flow with a Normal Shock

This calculation was initiated with an initial condition which consisted of a 2-D highly damped ($\sigma = 0.5$) solution with a simple boundary layer correction applied in the vicinity of the side wall ($y = 0$). With these initial conditions, it took about 80 time steps to reach an asymptotic steady-state solution for $\sigma_x = \sigma_y = \sigma_z = 0.5$. Then the calculation proceded with reduced σ_z ($= 0.05$) for another 60 time steps. Finally, an additional 50 time steps were advanced with $\sigma_x = \sigma_y = \sigma_z = 0.05$ to reach an asymptotic steady state. The calculated top wall pressure distribution is given in Fig. 16 while the computed bottom wall pressure distribution is shown in Fig. 17. As would be expected for this flow, the 3-D results agree quite well with the 2-D numerical results of Case (2) and the nominally 2-D experimental data (Ref. 20), except that the 3-D shock is slightly weaker than, and its position is slightly upstream of the 2-D shock. The variation of the wall static pressure in the spanwise direction is small, as is shown in Fig. 18, which depicts the pressure contours at various spanwise locations. The displayed region extends from two throat heights upstream of the throat to 6 throat heights downstream of the throat. The minimum contour level is 0.502 with a constant increment of 0.02. Figure 19 presents the streamwise Mach Number distribution. Points A are inside the side wall boundary layer and Points B are on the center (symmetry) plane. Both Points A and B are located slightly below the midplane of each cross-section. The spanwise variation of the Mach Number contours is illustrated in Fig 20, in which the displayed region is the same as that in Fig. 18, but the minimum contour level is 0.432 with a constant increment of 0.032. It is noted that, contrary to the static pressure distribution, the Mach Number distribution exhibits strong spanwise dependence.

As mentioned above, the strength of the three-dimensional shock is slightly weaker than its two-dimensional counterpart; such a three-dimensional effect on the shock strength is also reported in a recent work on the inviscid transonic flow in an axial compressor rotor (Ref. 28). Further, the position of the weaker 3-D shock is slightly upstream of the position of its corresponding stronger 2-D shock; this is consistent with the fact that the flows are in a supercritically operated inlet/diffuser.

Concluding Remarks

Due to the complexity of the fluid mechanics invloved in the terminal
shock region of the inlet, the three-dimensional ensemble-averaged compressible
time-dependent Navier-Stokes equations in conjunction with suitable turbulence
modeling and shock capturing technique have been used to study the terminal
shock type of flow problems. The numerical scheme for solving the governing
equations is based on a linearized block implicit approach which is embodied
in a general computer code termed "MINT". The MINT code has been applied to
calculate turbulent flows in various flight regimes occurring in a diffuser/
inlet model. These high Reynolds number calculations are: (1) 2-D, steady,
subsonic; (2) 2-D, steady, transonic with normal shock, (3) 2-D, steady,
supersonic with terminal shock, (4) 2-D, transient process of shock development
and (5) 3-D steady, transonic with normal shock. As an indication of the
validity of these computations, the numerical results obtained for the
2-D/3-D transonic diffuser flows have been compared with corresponding
experimental data, the calculated wall static pressure distributions agree
quite well with the experimentally measured data. Also studied is the role
of the artificial dissipation in the shock capturing technique, inappropriate choice
of the artificial dissipation will severely smear the shock. These extensive
and carefully designed calculations demonstrate the capabilities of the MINT
code for predicting the complex flows commonly occurring in the engine inlets.
Further investigations should concentrate on the problems concerning
the response of the terminal shock to the externally applied disturbances and
the effects of the turbulence modeling on the small scale flow properties.
In this respect, the turbulence models for three-dimensional terminal shock
flows are of particular concern.

APPENDIX - SOLUTION PROCEDURE [17]
Background

The solution procedure employs a consistently-split linearized block implicit (LBI) algorithm which has been discussed in detail in [13, 15]. There are two important elements of this method:

(1) the use of a noniterative formal time linearization to produce a fully-coupled linear multidimensional scheme which is written in "block implicit" form; and

(2) solution of this linearized coupled scheme using a consistent "splitting" (ADI scheme) patterned after the Douglas-Gunn [16] treatment of scalar ADI schemes.

The method is thus referred to as a split linearized block implicit (LBI) scheme. The method has several attributes:

(1) the noniterative linearization is efficient;

(2) the fully-coupled linearized algorithm eliminates instabilities and/or extremely slow convergence rates often attributed to methods which employ ad hoc decoupling and linearization assumptions to identify nonlinear coefficients which are then treated by lag and update techniques;

(3) the splitting or ADI technique produces an efficient algorithm which is stable for large time steps and also provides a means for convergence acceleration for further efficiency in computing steady solutions;

(4) intermediate steps of the splitting are consistent with the governing equations, and this means that the "physical" boundary conditions can be used for the intermediate solutions. Other splittings which are inconsistent can have severe difficulties in satisfying physical boundary conditions [15].

(5) the convergence rate and overall efficiency of the algorithm are much less sensitive to mesh refinement and redistribution than algorithms based on explicit schemes or which employ ad hoc decoupling and linearization assumptions. This is important for accuracy and for computing turbulent flows with viscous sublayer resolution; and

(6) the method is general and is specifically designed for the complex systems of equations which govern multiscale viscous flow in complicated geometries.

This same algorithm was later considered by Beam and Warming [25], but the ADI splitting was derived by approximate factorization instead of the Douglas-Gunn procedure. They refer to the algorithm as a "delta form" approximate factorization scheme. This scheme replaced an earlier non-delta form scheme [26], which has inconsistent intermediate steps.

Spatial Differencing and Artificial Dissipation

The spatial differencing procedures used are a straightforward adaption of those used in [13] and elsewhere. Three-point central difference formulas are used for spatial derivatives, including the first-derivative convection and pressure gradient terms. This has an advantage over one-sided formulas in flow calculations subject to "two-point" boundary conditions (virtually all viscous or subsonic flows), in that all boundary conditions enter the algorithm implicitly. In practical flow calculations, artificial dissipation is usually needed and is added to control high-frequency numerical oscillations which otherwise occur with the central-difference formula.

In the present investigation, artificial (anisotropic) dissipation terms of the form

$$\sum_j \frac{d_j}{h_j^2} \frac{\partial^2 u_k}{\partial x_j^2}$$

(1)

are added to the right-hand side of each (k-th) component of the momentum equation, where h_j is the metric coefficient and for each coordinate direction x_j, the dimensionless artificial diffusivity d_j is positive and is chosen as the larger of zero and the local quantity μ_e ($\sigma\ Re_{\Delta x_j} -1$)/ Re. Here, μ_e is the effective dynamic viscosity and the local cell Reynolds number $Re_{\Delta x_j}$ for the j-th direction is defined by

$$Re_{\Delta x_j} = Re \ |\rho u_j| \ \Delta x_j / \mu_e$$

(2)

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This treatment lowers the formal accuracy to $O(\Delta x)$, but the functional form is such that accuracy in representing physical shear stresses in thin shear layers with small normal velocity is not seriously degraded. This latter property follows from the anisotropic form of the dissipation and the combination of both small normal velocity and small grid spacing in thin shear layers.

<div align="center">Split LBI Algorithm</div>

Linearization and Time Differencing

The system of governing equations to be solved consists of three/four equations: continuity and two/three components of momentum equation in three/four dependent variables: ρ, u, v, w. Using notation similar to that in [13], at a single grid point this system of equations can be written in the following form:

$$\partial H(\phi)/\partial t = D(\phi) + S(\phi) \tag{3}$$

where ϕ is the column-vector of dependent variables, H and S are column-vector algebraic functions of ϕ, and D is a column vector whose elements are the spatial differential operators which generate all spatial derivatives appearing in the governing equation associated with that element.

The solution procedure is based on the following two-level implicit time-difference approximations of (3):

$$(H^{n+1} - H^n)/\Delta t = \beta(D^{n+1} + S^{n+1}) + (1-\beta)(D^n + S^n) \tag{4}$$

where, for example, H^{n+1} denotes $H(\phi^{n+1})$ and $\Delta t = t^{n+1} - t^n$. The parameter β $(0.5 \leq \beta \leq 1)$ permits a variable time-centering of the scheme, with a truncation error of order $[\Delta t^2, (\beta - 1/2)\Delta t]$.

A local time linearization (Taylor expansion about ϕ^n) of requisite formal accuracy is introduced, and this serves to define a linear differential operator L (cf. [13]) such that

$$D^{n+1} = D^n + L^n(\phi^{n+1} - \phi^n) + O(\Delta t^2) \tag{5}$$

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Similarly, $\qquad$ (6)

$$H^{n+1} = H^n + (\partial H/\partial \phi)^n \; (\phi^{n+1} - \phi^n) + 0 \; (\Delta t^2)$$

$$S^{n+1} = S^n + (\partial S/\partial \phi)^n \; (\phi^{n+1} - \phi^n) + 0 \; (\Delta t^2) \qquad (7)$$

Eqs. (5-7) are inserted into Eq. (4) to obtain the following system which is linear in ϕ^{n+1}

$$(A - \beta \Delta t \; L^n) \; (\phi^{n+1} - \phi^n) = \Delta t \; (D^n + S^n) \qquad (8)$$

and which is termed a linearized block implicit (LBI) scheme. Here, A denotes a square matrix defined by

$$A \equiv (\partial H/\partial \phi)^n - \beta \Delta t \; (\partial S/\partial \phi)^n \qquad (9)$$

Eq. (8) has $0 \; (\Delta t)$ accuracy unless $H \equiv \phi$, in which case the accuracy is the same as Eq. (4).

Special Treatment of Diffusive Terms

The time differencing of diffusive terms is modified to accomodate cross-derivative terms and also turbulent viscosity and artificial dissipation coefficients which depend on the solution variables. Although formal linearization of the convection and pressure gradient terms and the resulting implicit coupling of variables is critical to the stability and rapid convergence of the algorithm, this does not appear to be important for the turbulent viscosity and artificial dissipation coefficients. Since the relationship between μ_e and d_j and the mean flow variables is not conveniently linearized, these diffusive coefficients are evaluated explicitly at t^n during each time step. Notationally, this is equivalent to neglecting terms proportional to $\partial \mu_e/\partial \phi$ or $\partial d_j/\partial \phi$ in L^n, which are formally present in the Taylor expansion (5), but retaining all terms proportional to μ_e or d_j in both L^n and D^n.

It has been found through extensive experience that this has little if any effect on the performance of the algorithm. This treatment also has the added benefit that the turbulence model equations can be decoupled from the system of mean flow equations by an appropriate matrix partitioning (cf. [15]) and solved separately in each step of the ADI solution procedure. This reduces the block size of the block tridiagonal systems which must be solved in each step and thus reduces the computational labor.

In addition, the viscous terms in the present formulation include a number of spatial cross-derivative terms. Although it is possible to treat cross-derivative terms implicitly within the ADI treatment which follows, it is not at all convenient to do so, and consequently, all cross-derivative terms are evaluated explicitly at t^n. For a scalar model equation representing combined convection and diffusion, it has been shown by Beam and Warming that the explicit treatment of cross-derivative terms does not degrade the unconditional stability of the present algorithm. To preserve notational simplicity, it is understood that all cross-derivative terms appearing in L^n are neglected but are retained in D^n. It is important to note that neglecting terms in L^n has no effect on steady solutions of Eq. (8), since $\phi^{n+1} - \phi^n \equiv 0$ and thus Eq. (8) reduces to the steady form of the equations: $D^n + S^n = 0$. Aside from stability considerations, the only effect of neglecting terms in L^n is to introduce an $0 \, (\Delta t)$ truncation error.

Consistent Splitting of the LBI Scheme

To obtain an efficient algorithm, the linearized system (8) is split using ADI techniques. To obtain the split scheme, the multidimensional operator L is rewritten as the sum of three "one-dimensional" sub-operators L_i (i = 1, 2, 3) each of which contains all terms having derivatives with respect to the i-th coordinate. The split form of Eq. (8) can be derived either as in [13, 15] by following the procedure described by Douglas and Gunn [16] in their generalization and unification of scalar ADI schemes, or using approximate factorization. For the present system of equations, the split algorithm is given by

$$(A - \beta \Delta t L_1^n) \, (\phi^* - \phi^n) = \Delta t \, (D^n + S^n) \qquad (10a)$$

$$(A - \beta \Delta t L_2^n) \, (\phi^{**} - \phi^n) = A \, (\phi^* - \phi^n) \qquad (10b)$$

$$(A - \beta \Delta t L_3^n) \, (\phi^{n+1} - \phi^n) = A \, (\phi^{**} - \phi^n) \qquad (10c)$$

where ϕ^* and ϕ^{**} are consistent intermediate solutions. If spatial derivatives appearing in L_i and D are replaced by three-point difference formulas, as indicated previously, then each step in Eqs. (10a-c) can be solved by a block-tridiagonal elimination.

Combining Eqs. (10a-c) gives

$$(A - \beta \Delta t L_1^n) \, A^{-1} \, (A - \beta \Delta t L_2^n) \, A^{-1} \, (A - \beta \Delta t L_3^n) \, (\phi^{n+1} - \phi^n)$$

$$= \Delta t \, (D^n + S^n) \qquad (11)$$

which approximates the unsplit shceme (8) to 0 (Δt^2). Since the intermediate steps are also consistent approximations for Eq. (8), physical boundary conditions can be used for ϕ^* and ϕ^{**} [13, 15]. Finally, since the L_i are homogeneous operators, it follows from Eqs. (10a-c) that steady solutions have the property that $\phi^{n+1} = \phi^* = \phi^{**} = \phi^n$ and satisfy

$$D^n + S^n = 0 \tag{12}$$

The steady solution thus depends only on the spatial difference approximations used for (12), and does not depend on the solution algorithm itself.

REFERENCES

1. Buggeln, R.C., McDonald, H., Levy, R. and Kreskovsky, J.P.: Development of a Three-Dimensional Supersonic Inlet Flow Analysis. NASA CR 3218, 1980.

2. Buggeln, R.C., McDonald, H., Kreskovsky, J.P. and Levy, R.: Computation of Three-Dimensional Supersonic Flow in Inlets. AIAA Paper 80-1094, 1980.

3. Anderson, B.H. and Towne, C.E.: Numerical Simulation of Supersonic Inlets Using a Three-Dimensional Viscous Flow Analysis. AIAA Paper 80-0384, 1980.

4. Buggeln, R.C., McDonald, H., Kim, Y.N.: Computation of Multidimensional Viscous Supersonic Flow. AIAA-83-0177.

5. Levy, R., Briley, W.R. and McDonald, H.: Viscous Primary/Secondary Flow Analysis for Use With Nonorthogonal Coordinate Systems. AIAA-83-0556.

6. Shamroth, S.J., Gibeling, H.J. and McDonald, H.: A Navier-Stokes Solution for Laminar and Turbulent Flow Through a Cascade of Airfoils. AIAA Paper No. 80-1426, 1980.

7. Gibeling, H.J., Shamroth, S.J. and Eiseman, P.R.: Analysis of Strong-Interaction Dynamic Stall for Laminar Flow on Airfoils. NASA CR-2969, April 1978.

8. Thomas, P.D. and Lombard, C.K.: Geometric Conservation Law and its Application to Flow Computations on Moving Grids, AIAA Journal, Vol. 17, No. 10, pp. 1030-1037, 1979.

9. Oh, Y.H.: An Analytic Transformation Technique for Generating Uniformly Spaced Computational Mesh, Final Report, NASA-Langley Research Grant NSG 1087, October, 1978.

10. McDonald, H. and Camarata, F.J.: An Extended Mixing Length Approach for Computing the Turbulent Boundary Layer Development, Proceedings Computation of Turbulent Boundary Layers - 1968 AFOSR-IFP Stanford Conference, Vol. 1, pp. 83-98, 1969.

11. Van Driest, E.R.: On Turbulent Flow Near a Wall. Journal of the Aeronautical Sciences, November 1956.

12. Briley, W.R. and McDonald, H.: Computation of Three-Dimensional Horseshoe Vortex Flow Using the Navier-Stokes Equations. Seventh International Conference on Numerical Methods in Fluid Dynamics, 1980.

13. Briley, W.R. and McDonald, H.: Solution of the Multidimensional Compressible Navier-Stokes Equations by a Generalized Implicit Method. Journal of Computational Physics, Vol. 24, pp. 372-397, 1977.

14. Lindemuth, I. and Killeen, J.: Alternating Direction Implicit
    Techniques for Two-Dimensional Magnetohydrodynamic Calculations.
    Journal of Computational Physics, Vol. 13, pp. 181, 1973.

15. Briley, W.R. and McDonald, H.: On the Structure and Use of Linearized
    Block Implicit Schemes. Journal of Computational Physics, Vol. 34,
    pp. 54-72, 1980.

16. Douglas, J. and Gunn, J.E.: A General Formulation of Alternating
    Direction Methods. Numerische Math., Vol. 6, pp. 428-453, 1964.

17. Briley, W.R., Buggeln, R.C. and McDonald, H.: Computation of Laminar
    and Turbulent Flow in 90 Degree Square Duct and Pipe Bends Using the
    Navier-Stokes Equations. SRA Rpt. R82-920009-F, 1982.

18. Shamroth, S.J., McDonald, H. and Briley, W.R.: A Navier-Stokes
    Solution for Transonic Flow Through a Cascade. SRA Rpt. 81-920007-F,
    1982.

19. Shamroth, S.J. and McDonald, H.: An Assessment of an Ensemble-Averaged
    Navier-Stokes Calculation Procedure for Cascade Flow Fields. SRA
    Rpt. 82-920011-F, 1982.

20. Bogar, T.J., Sajben, M. and Kroutil, J.C.: Characteristic Frequency
    and Length Scales in Transonic Diffuser Flow Oscillations. AIAA-81-1291.

21. Salmon, J.T., Bogar, T.J. and Sajben, M.: Laser Velocimeter Measurements
    in Unsteady, Separated, Transonic Diffuser Flows. AIAA-81-1197.

22. Musker, A.J.: Explicit Expression for the Smooth Wall Velocity
    Distribution in a Turbulent Boundary Layer. AIAA J. Vol. 17, No. 6,
    pp. 655-657, 1979.

23. Van Driest, E.R.: Turbulent Boundary Layer in Compressible Fluids.
    Journal of the Aeronautical Sciences, Vol. 18, pp. 145-160 and 216, 1951.

24. Sajben, M., Bogar, T.J. and Kroutil, J.C.: Forced Oscillation
    Experiments in Supercritical Diffuser Flows with Application to Ramjet
    Instabilities. AIAA-81-1487.

25. Beam, R.M. and Warming, R.F.: An Implicit Factored Scheme for the Com-
    pressible Navier-Stokes Equations. AIAA Journal, Vol. 16, pp. 393-402, 1978.

26. Beam, R.M. and Warming, R.F.: An Implicit Finite-Difference Algorithm for
    Hyperbolic Systems in Conservation-Law Form. J.Comp. Physics. Vol. 22,
    pp. 87-110, 1976.

27. McDonald, H. and Briley, W.R.: Some Observations on Numerical Solutions
    of the Three-Dimensional Navier-Stokes Equations. Symposium on
    Numerical and Physical Aspects of Aerodynamic Flows. January 1981.

28. Xu, J.-z., Jiang, Z.-r., Yang, J.-s., Zhang, Y. and Du, Z.-s.: An
    Aerothermodynamic Analysis of Transonic Compressor Rotors Containing
    Three-Dimensional Shocks. J. of Engineering For Power, Vol. 104,
    pp. 386-393, April 1982.
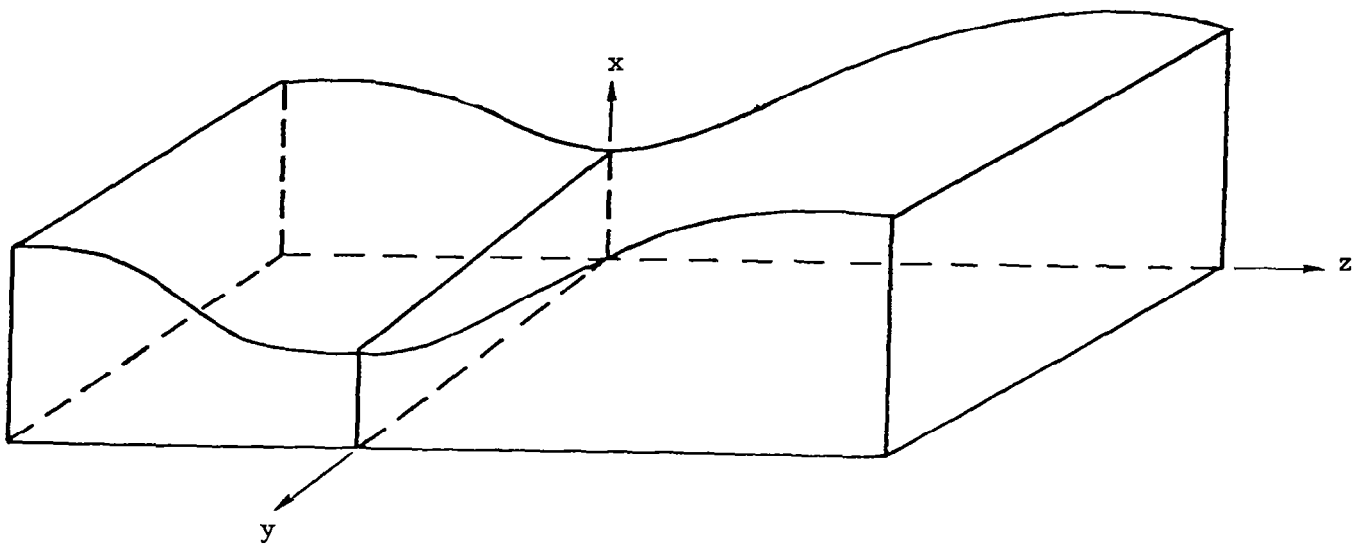
Fig. 1 — Schematic of the inlet/diffuser model.
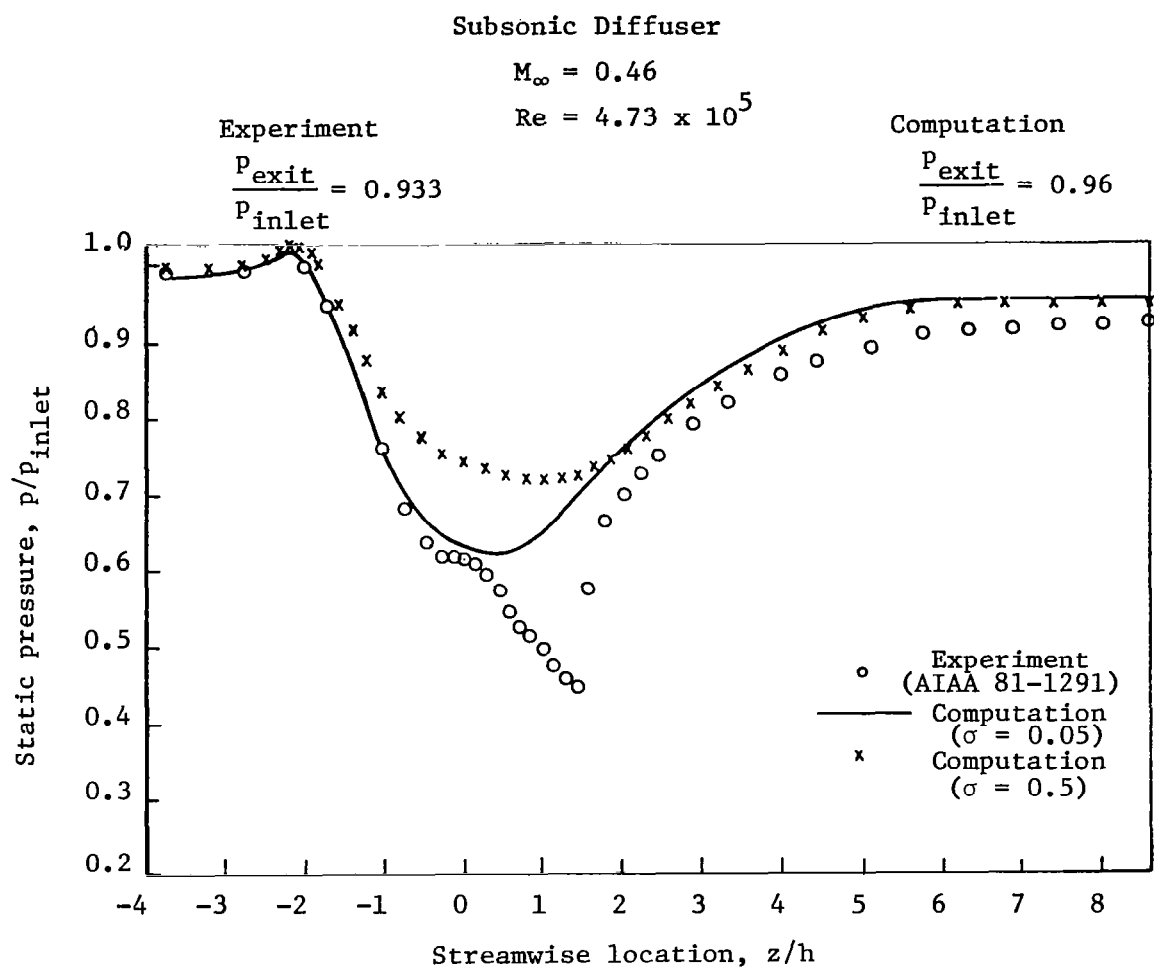
Fig. 2 − Top wall static pressure distribution

Fig. 3 - Bottom wall static pressure distribution

Transonic Diffuser

$M_\infty = 0.46$

$Re = 4.73 \times 10^5$

Experiment

$\dfrac{p_{exit}}{p_{inlet}} = 0.933$

Computation

$\dfrac{p_{exit}}{p_{inlet}} = 0.933$

Static pressure, p/p_{inlet}

Streamwise location, z/h

Experiment (AIAA 81-1291)

Computation ($\sigma = 0.05$)

Computation ($\sigma = 0.5$)
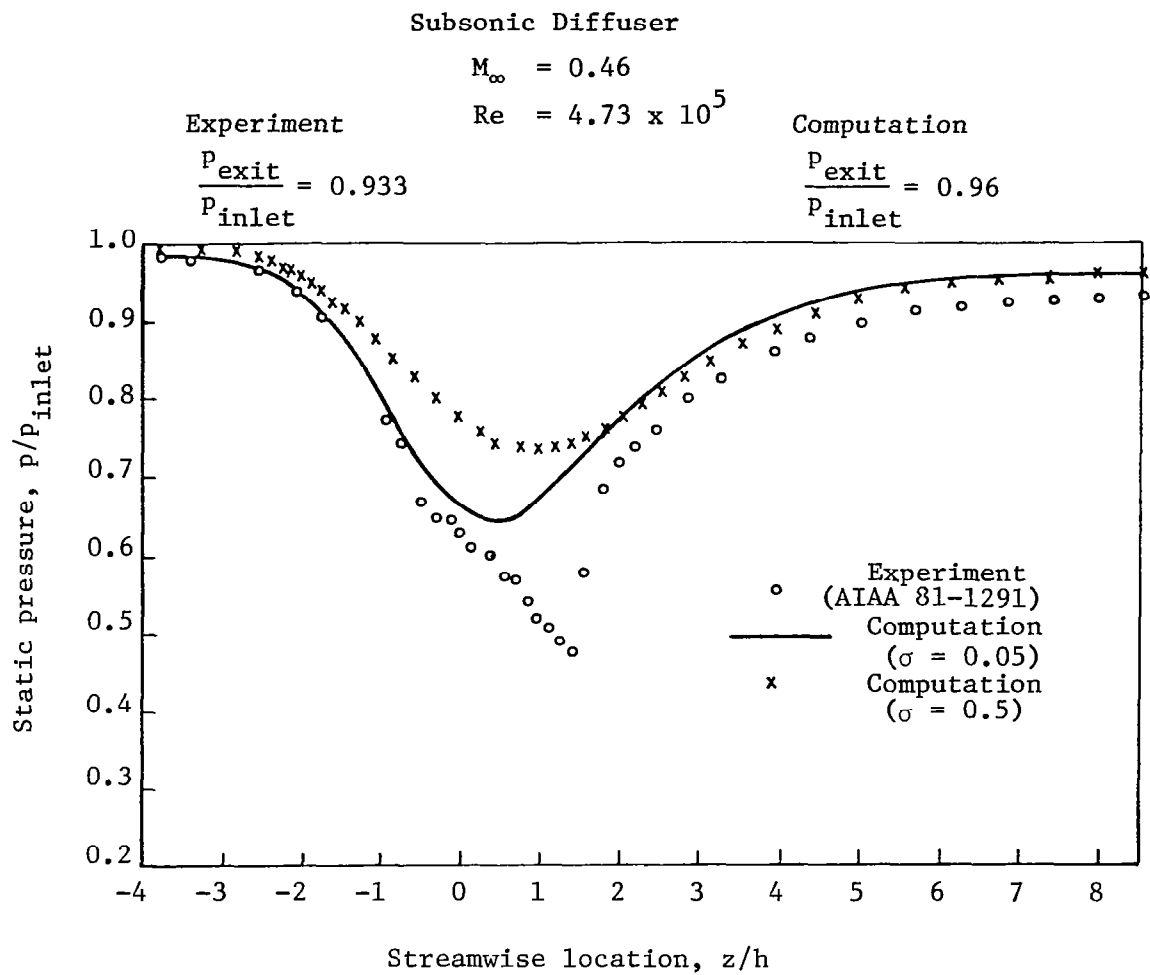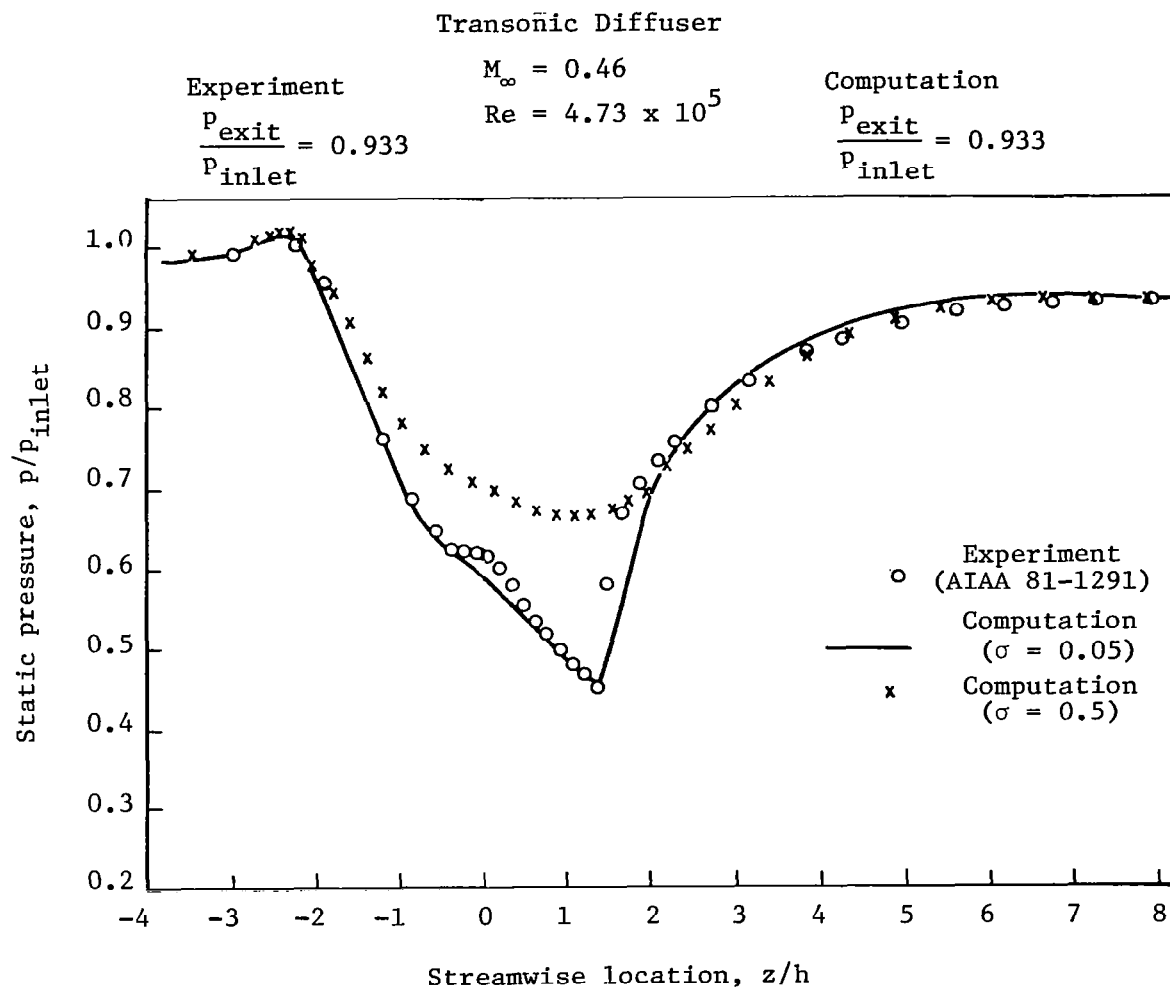
Fig. 4 - Top wall static pressure distribution.
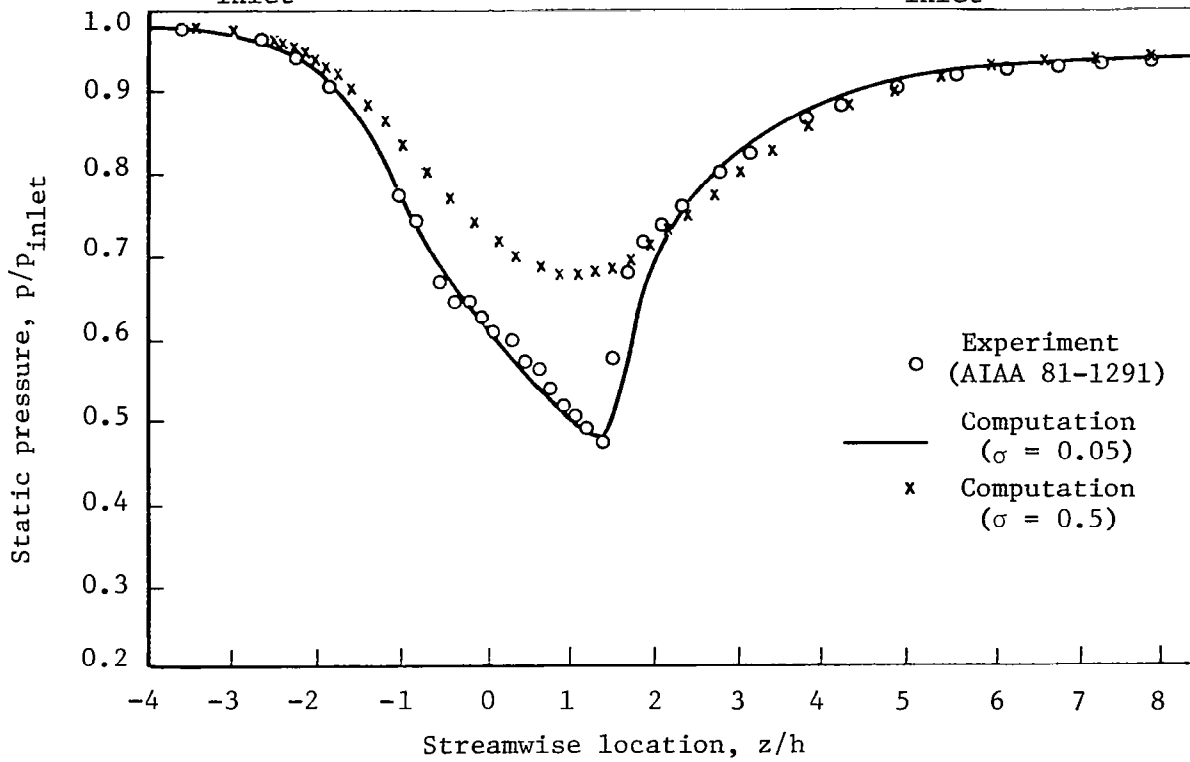
Fig. 5 - Bottom wall static pressure distribution.

Transonic Diffuser

$M_\infty = 0.46$

$Re = 4.73 \times 10^5$

Calculation
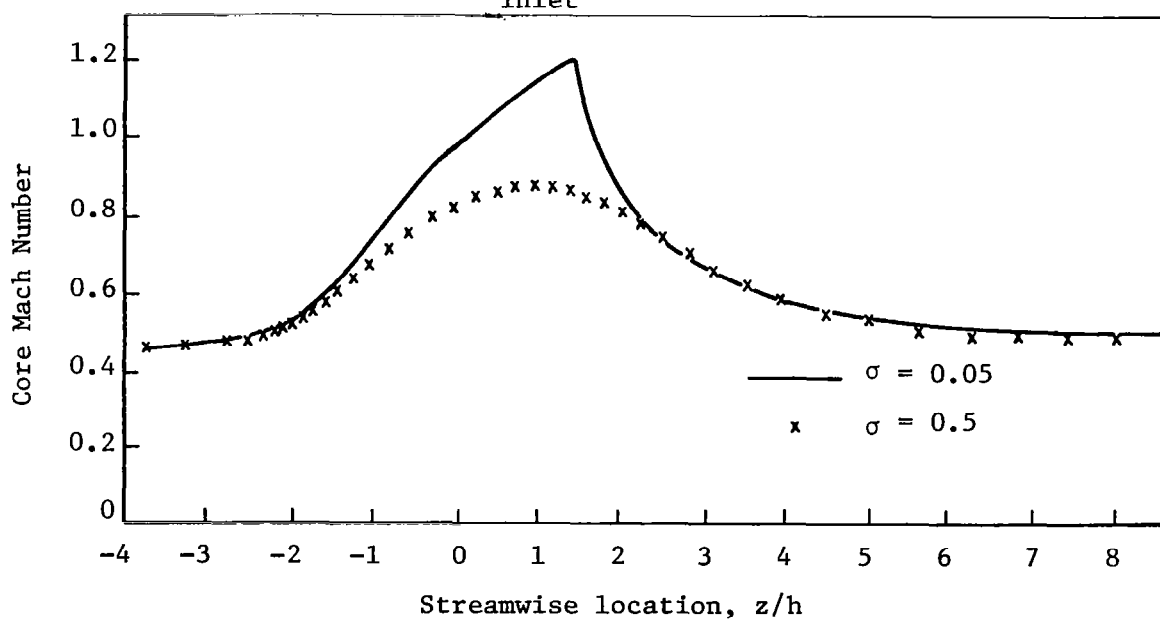
$$\frac{P_{exit}}{P_{inlet}} = 0.933$$

Fig. 6 – Core Mach number distribution and effects
of artificial dissipation.

Supersonic Inlet

$M_\infty = 1.90$

$Re = 4.73 \times 10^5$

$\dfrac{P_{exit}}{P_{inlet}} = 5.70$
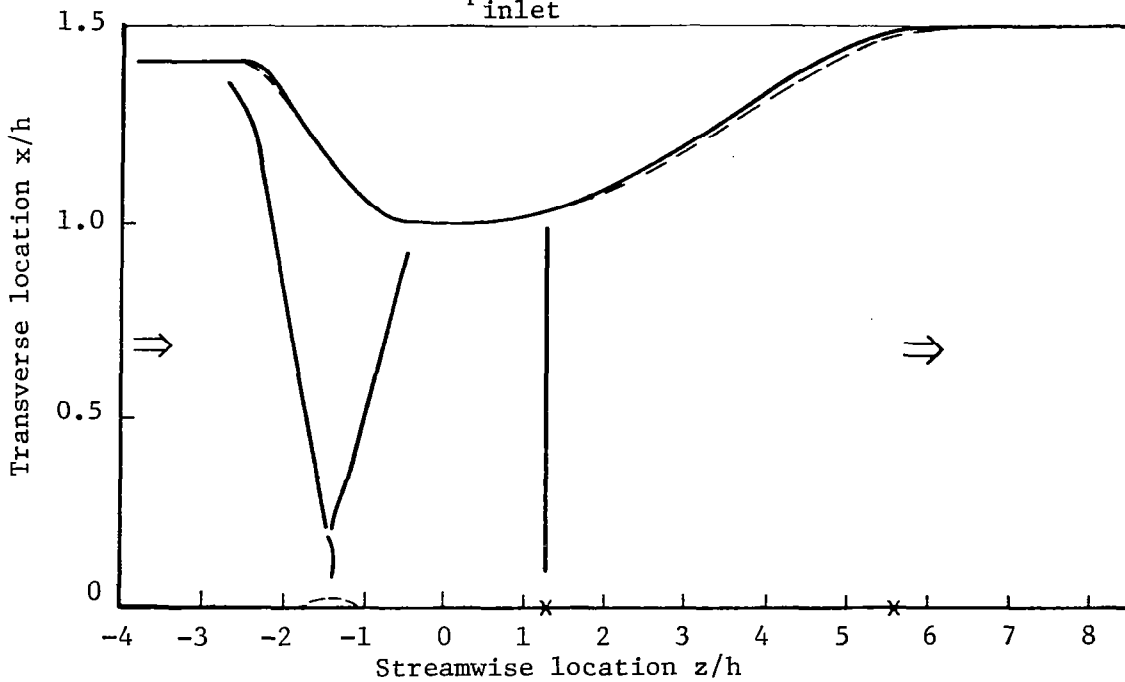
Note: The scale in transverse direction is 5 times larger than the scale in streamwise direction.

Fig. 7 - Schematic flow field.
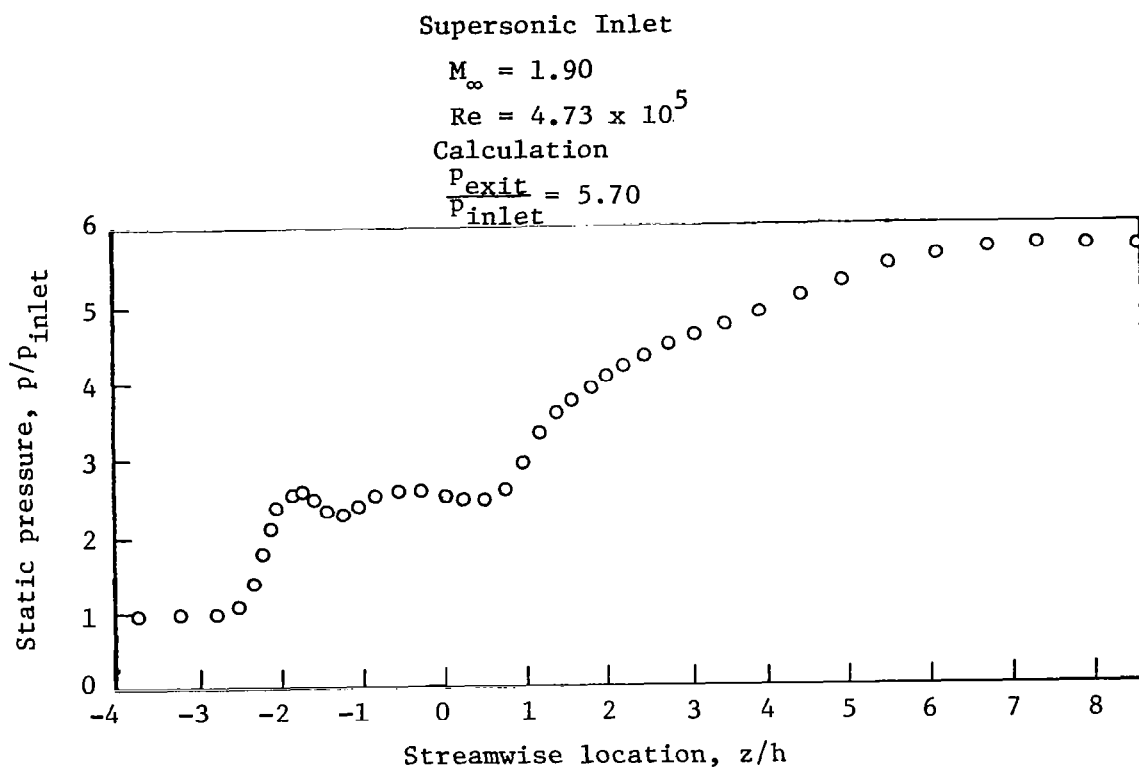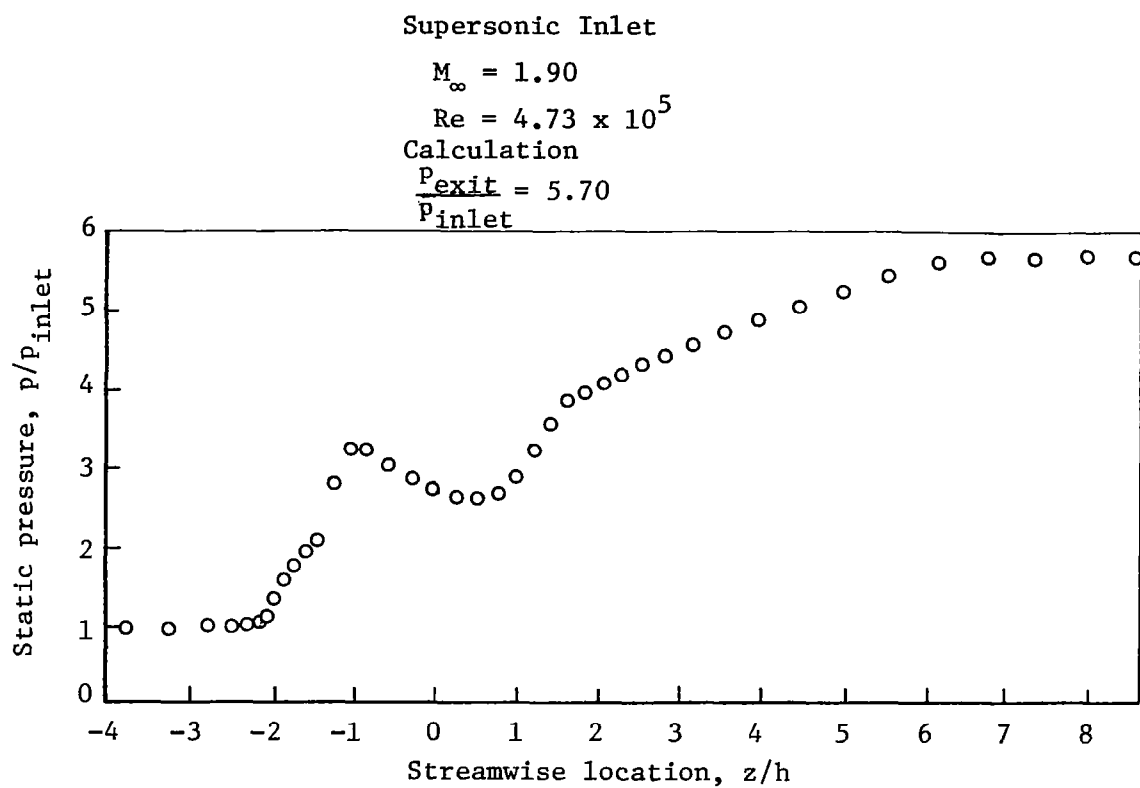
44

Supersonic Inlet

$M_\infty = 1.90$

$Re = 4.73 \times 10^5$

Calculation

$\dfrac{P_{exit}}{P_{inlet}} = 5.70$

Fig. 8 — Top wall static pressure distribution.

Supersonic Inlet

$M_\infty = 1.90$

$Re = 4.73 \times 10^5$

Calculation

$\dfrac{P_{exit}}{P_{inlet}} = 5.70$

Fig. 9 — Bottom wall static pressure distribution.

z/h=-3.75   z/h=0   z/h=3.4

(a) Subsonic diffuser

z/h=-3.75   z/h=0   z/h=3.4

(b) Transonic diffuser

z/h=-3.75   z/h=0   z/h=3.4
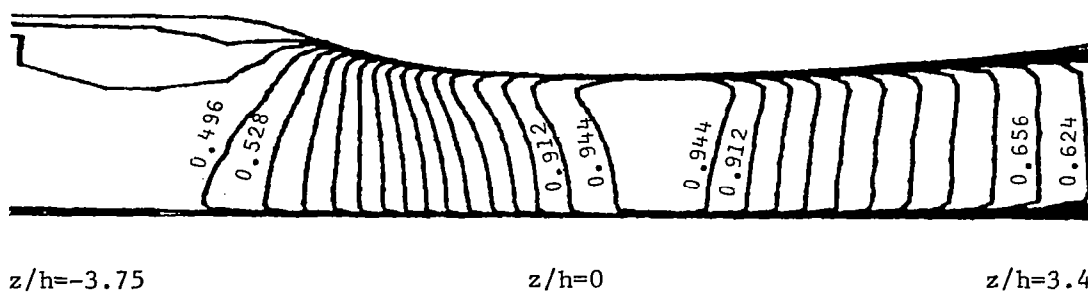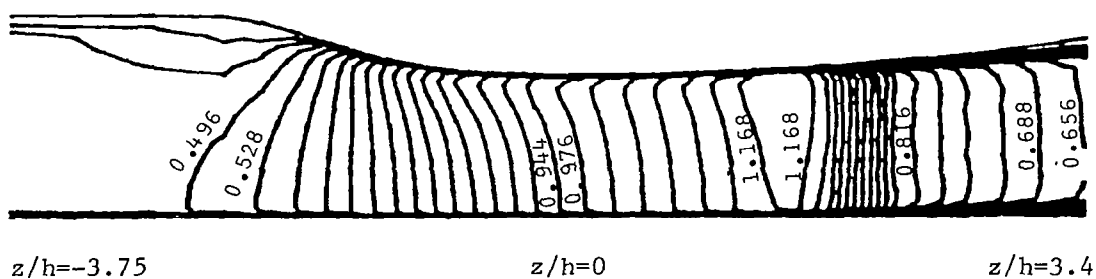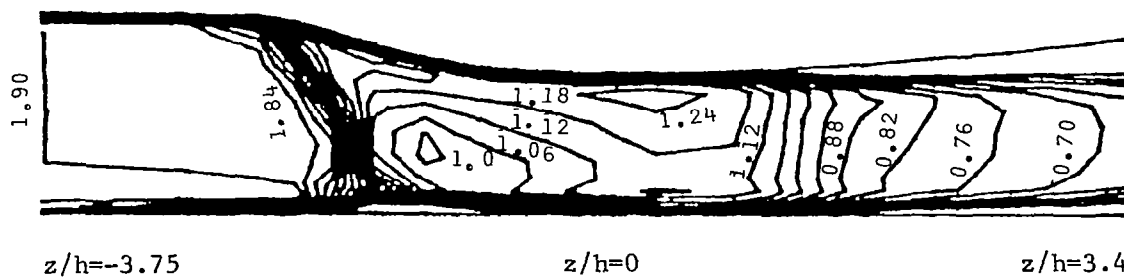
(c) Supersonic inlet

Fig. 10 – Mach number contours.

z/h=-3.75   z/h=0   z/h=3.4

(a) Subsonic diffuser

z/h=-3.75   z/h=0   z/h=3.4

(b) Transonic diffuser

z/h=-3.75   z/h=0   z/h=3.4
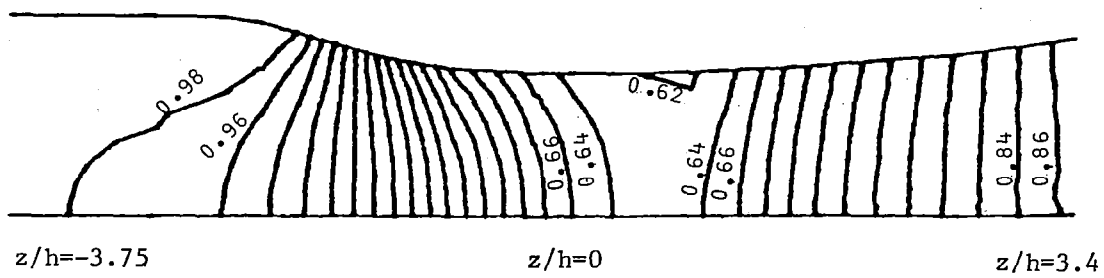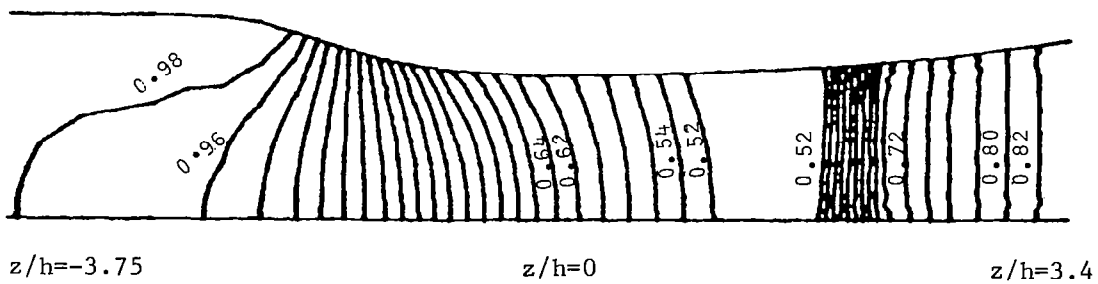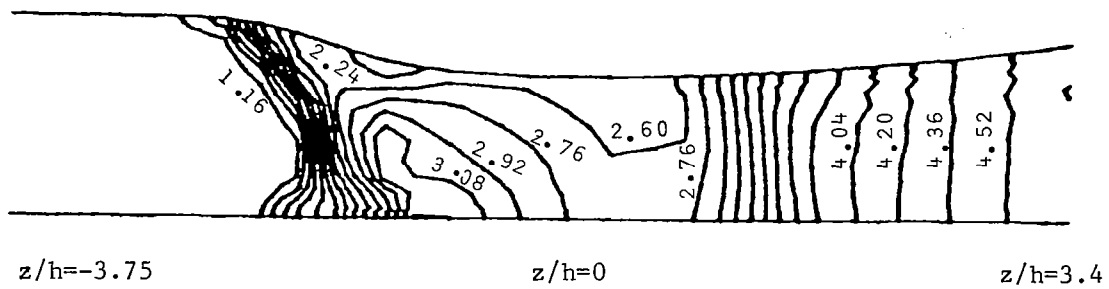
(c) Supersonic inlet

Fig. 11 - Dimensionless static pressure contours.

Formation of the shock (transonic diffuser)

$M_\infty = 0.46$

$Re = 4.73 \times 10^5$

t=0:

$\dfrac{P_{exit}}{P_{inlet}} = 0.96$

t>0:

$\dfrac{P_{exit}}{P_{inlet}} = 0.933$

+ t=0

o t=5 units

▼ t=10 units

x t=18 units

• asymptotic value experiment (AIAA 81-1291)
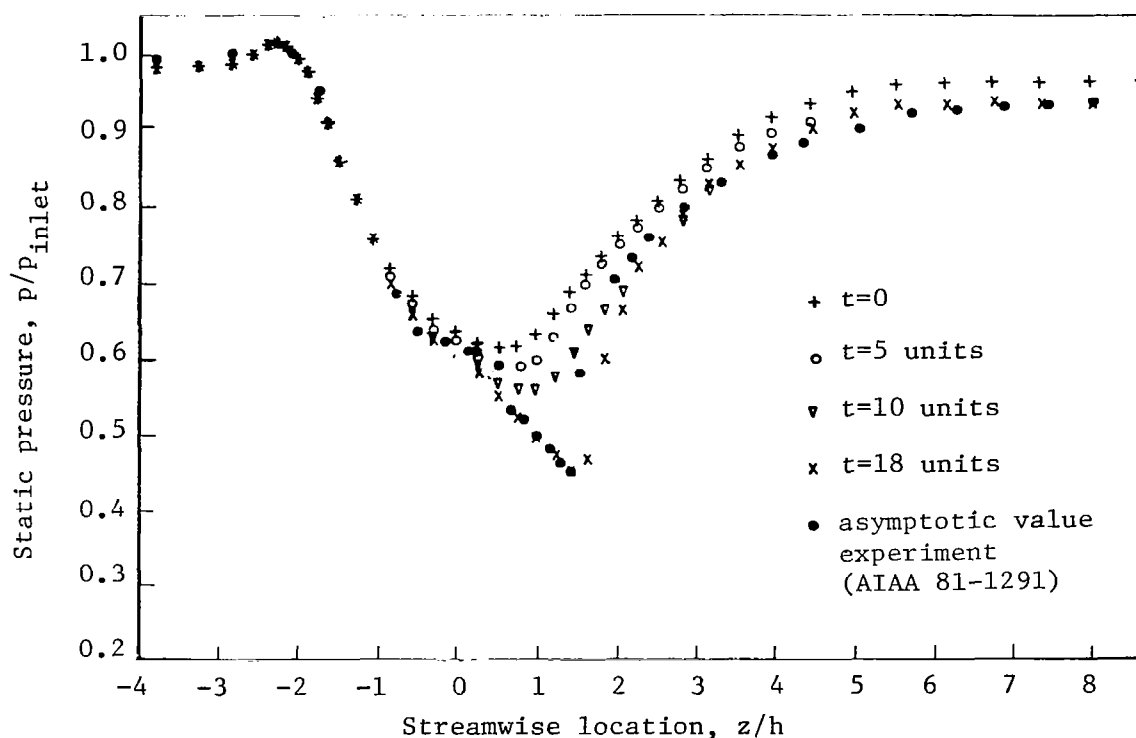
Fig. 12 — Time history of the top wall static pressure distribution. (1 time unit ≈ 0.3x10^{-3} sec)

Formation of the shock (transonic diffuser)

$$M_\infty = 0.46$$
$$Re = 4.73 \times 10^5$$

t=0:

$$\frac{P_{exit}}{P_{inlet}} = 0.96$$

t>0:

$$\frac{P_{exit}}{P_{inlet}} = 0.933$$

+   t=0

o   t=5 units

▽   t=10 units

x   t=18 units

●   asymptotic value
      experiment
      (AIAA 81-1291)

Static pressure, p/p_{inlet}

Streamwise location, z/h
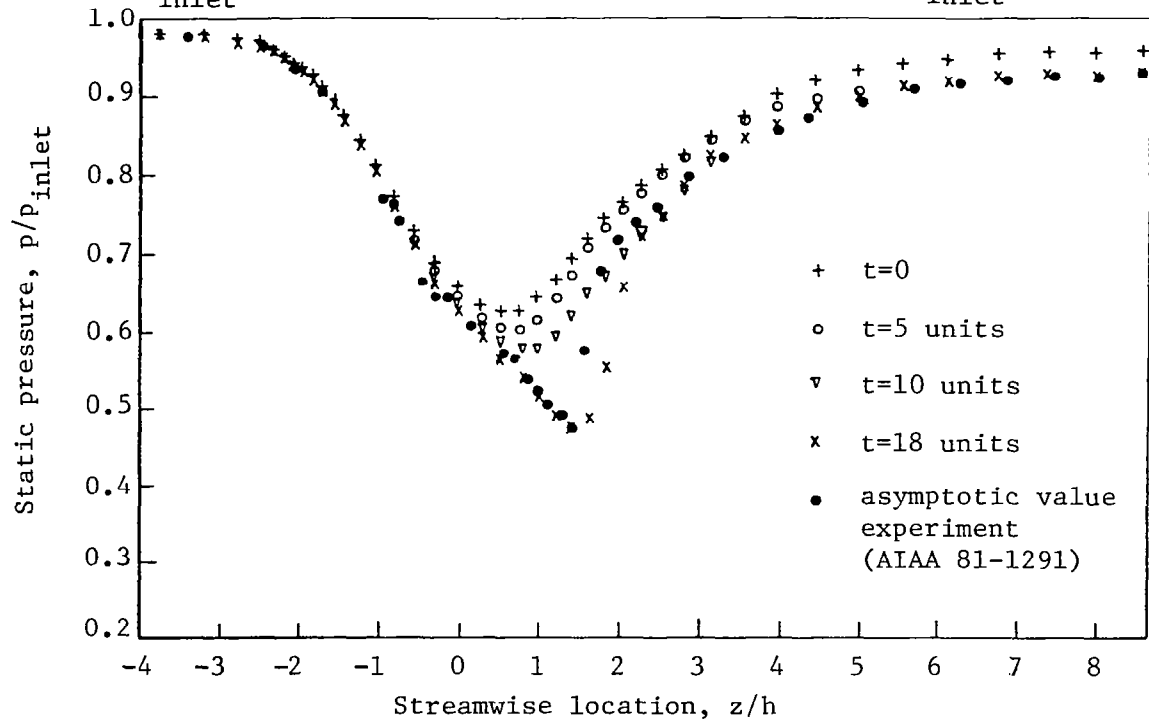
Fig. 13 — Time history of the bottom wall
static pressure distribution. (1 time unit $\approx 0.3 \times 10^{-3}$ sec)
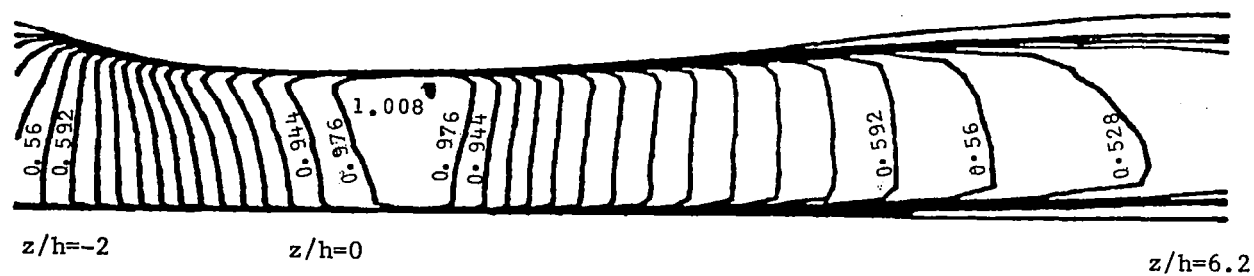
(a) t = 5.0 units
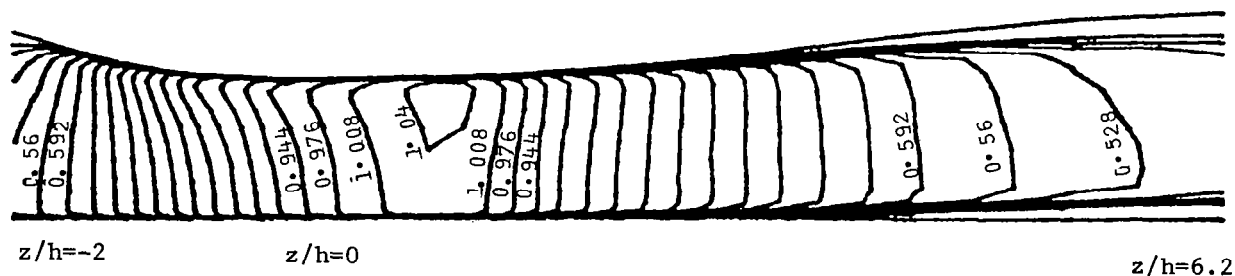
(b) t = 10.0 units
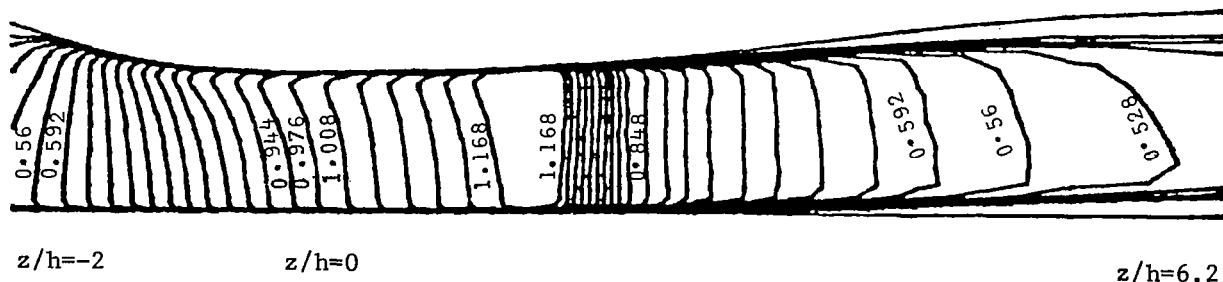
(c) t = 18.0 units

Fig. 14 - Time history of Mach number contours (transonic diffuser).
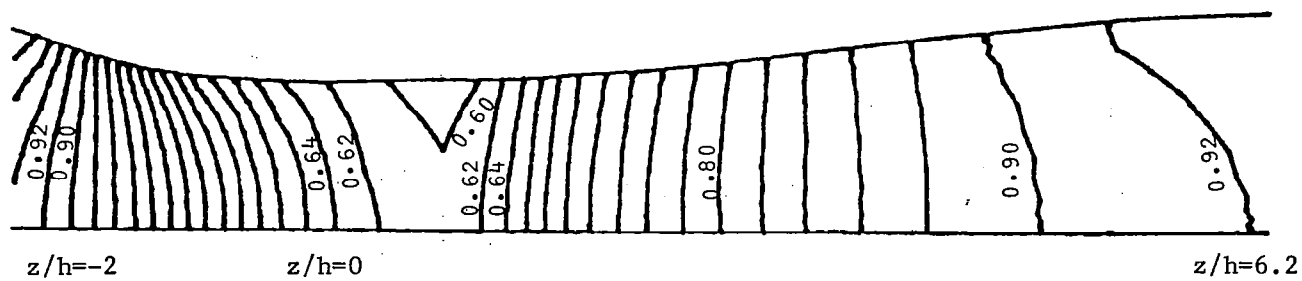
(a) t = 5.0 units
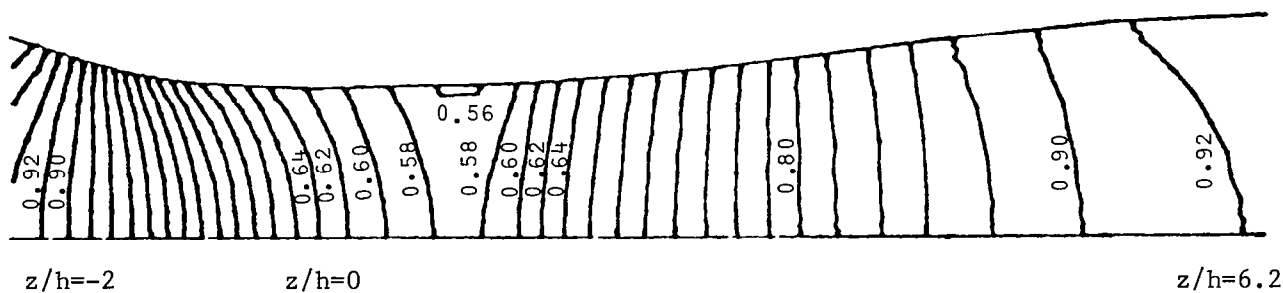
(b) t = 10.0 units
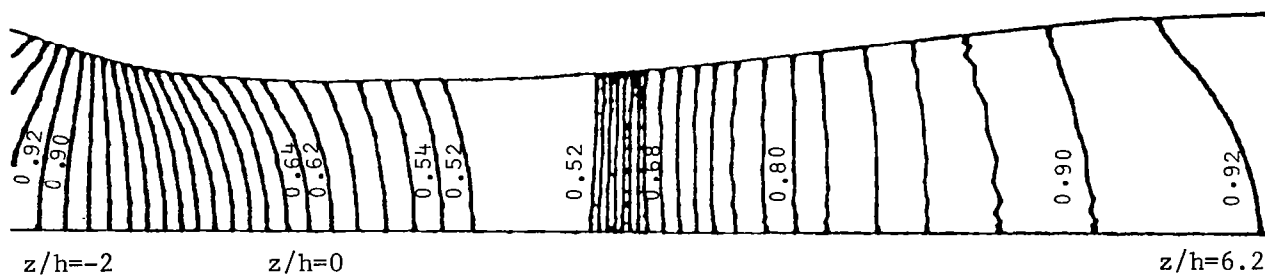
(c) t = 18.0 units

Fig. 15 – Time history of dimensionless static pressure contours
(transonic diffuser)

Transonic Diffuser (3-D)

$M_\infty = 0.46$

$Re = 4.73 \times 10^5$

Experiment

$$\frac{P_{exit}}{P_{inlet}} = 0.933$$

Calculation

$$\frac{P_{exit}}{P_{inlet}} = 0.933$$

o Experiment (Nominally 2-D)
  (AIAA 81-1291)

x Computation (2-D)

+ Computation (3-D)

Fig. 16 - Top wall static pressure distribution

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Transonic Diffuser (3-D)

$M_\infty = 0.46$

$Re = 4.73 \times 10^5$

Experiment

$\dfrac{P_{exit}}{P_{inlet}} = 0.933$

Calculation

$\dfrac{P_{exit}}{P_{inlet}} = 0.933$

o Experiment (Nominally 2-D)
   (AIAA 81-1291)
x Computation (2-D)
+ Computation (3-D)
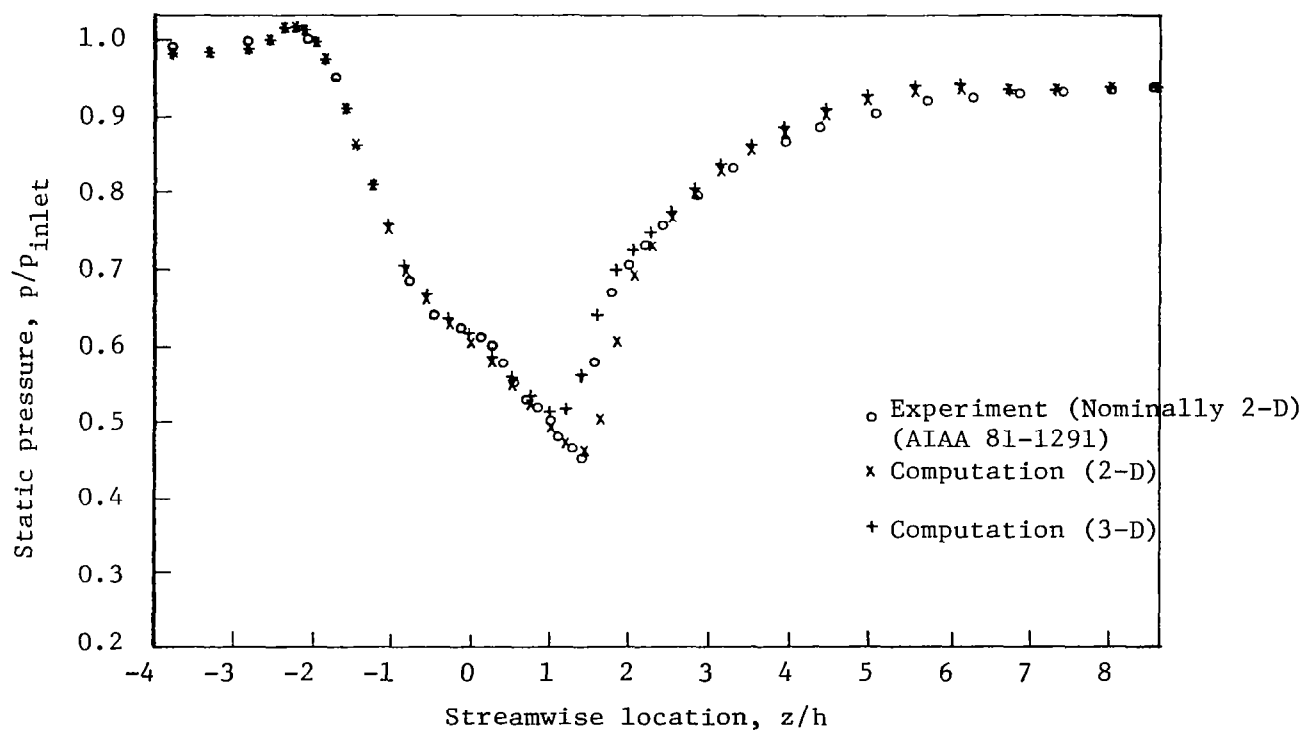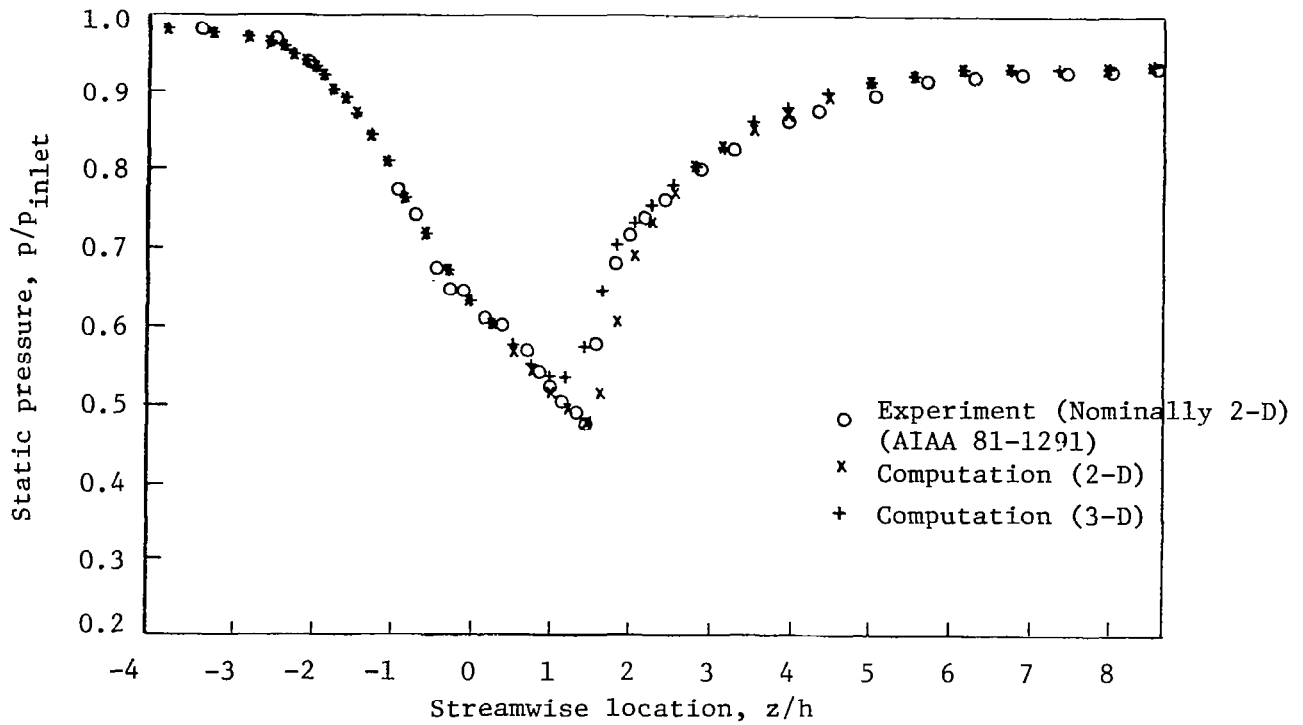
Fig. 17 - Bottom wall static pressure distribution

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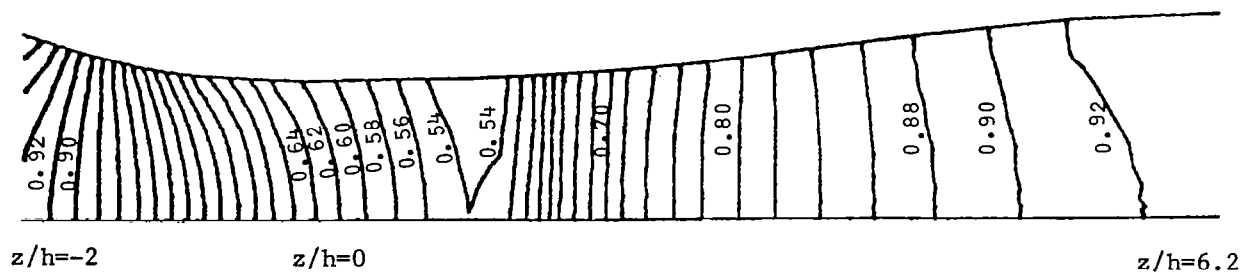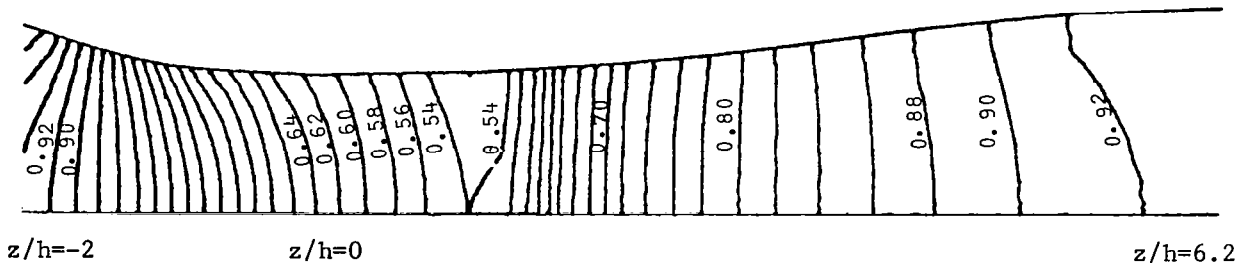
(a) $y/h = 0.216 \times 10^{-1}$

(b) $y/h = 0.732 \times 10^{-1}$
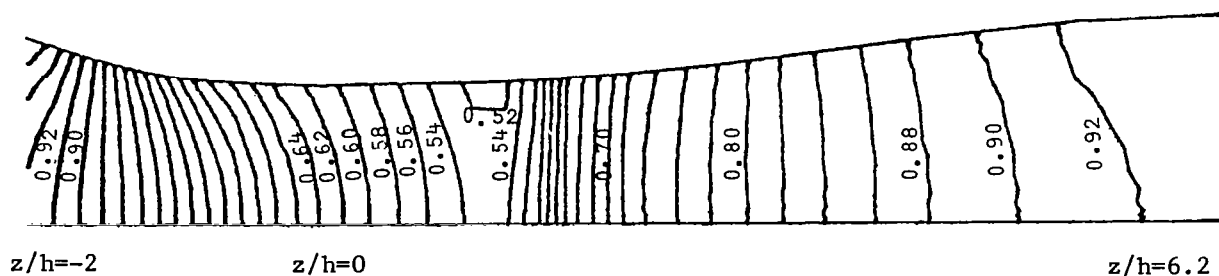
(c) $y/h = 1.50$

Fig. 18 – Dimensionless static pressure contours (3-D, transonic diffuser)

Transonic diffuser (3-D)
$$M_\infty = 0.46$$
$$Re = 4.73 \times 10^5$$

$$\frac{P_{exit}}{P_{inlet}} = 0.933$$

x/h

$(y/h)_A = 0.116 \times 10^{-1}$

$(y/h)_B = 1.5$

A

B

y/h

0

1.5

Mach Number

1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

-4 -3 -2 -1 0 1 2 3 4 5 6 7 8

Streamwise location, z/h

o Computation (3-D), at points A

x Computation (2-D), at points B

+ Computation (3-D), at points B
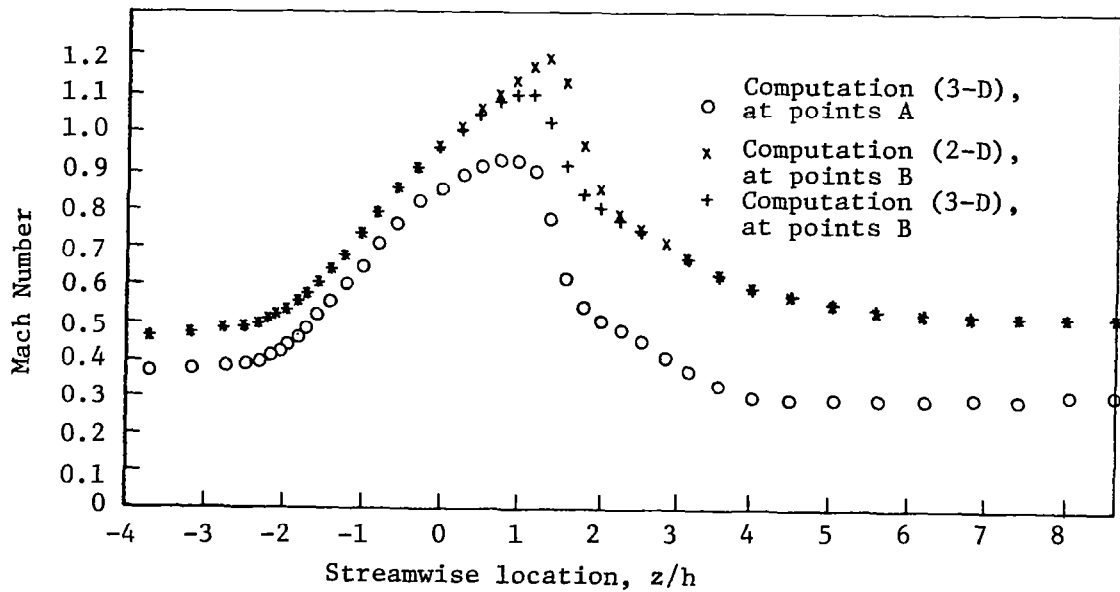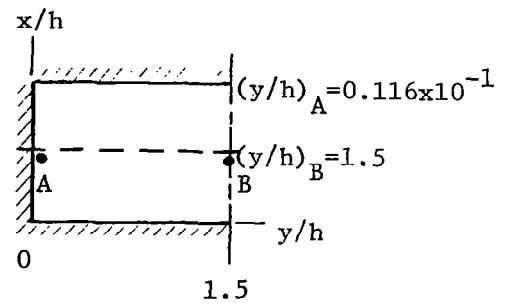
Fig. 19 - Streamwise Mach No. distribution

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z/h=-2   z/h=0   z/h=6.2

(a) y/h = 0.216 x 10^{-1}

z/h=-2   z/h=0   z/h=6.2

(b) y/h = 0.732 x 10^{-1}

z/h=-2   z/h=0   z/h=6.2
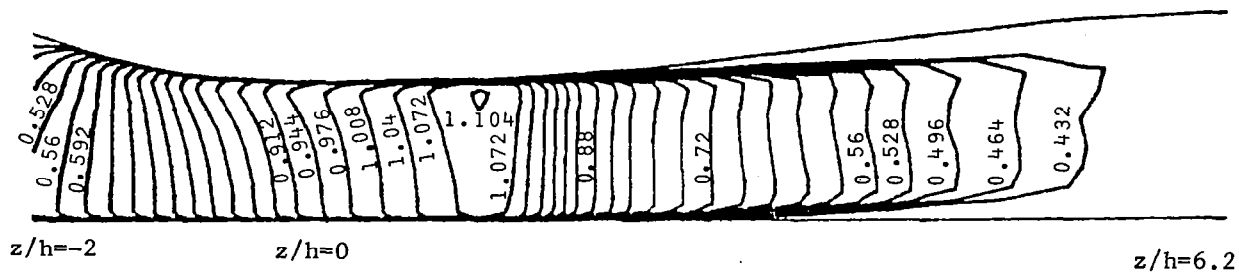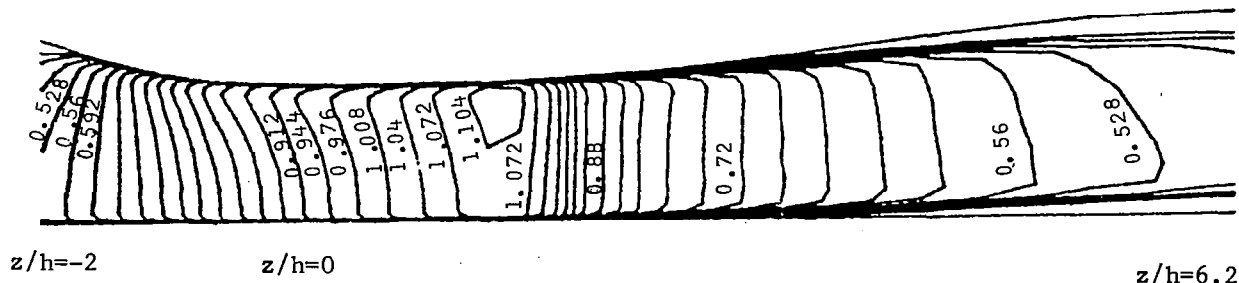
(c) y/h = 1.50

Fig. 20 – Mach Number contours (3-D, transonic diffuser)

User's Manual

The present manual is prepared for the INLTS.G01 CODE, which is the first version of the MINT INLET CODE. This particular version of the code is being stored on the Lewis IBM 370-3033 with TSS operating system and is written to solve the multi-dimensional ensemble-averaged time-dependent Navier-Stokes equations for turbulent, shocked flows in contoured, straight ducts with rectangular cross-sections. The coordinate system is nonorthogonal, contour-fitted and the equations are cast into the so-called strong conservation form. For the present time, the solution of the energy equation is replaced by the assumption that the total temperature is constant throughout the flowfield, although an energy equation can be activated. The effects of turbulence are represented by a mixing length model and the shock is captured by a second order artificial dissipation technique. The numerical procedure solves the time-dependent equations beginning with a specified initial condition and appropriate boundary conditions. Detailed descriptions of these various items can be found in the previous sections and will not be repeated here.

The INLTS.G01 CODE combines a BLOCK DATA program (BLKDAT) containing pertinent data statements, a main program (DAL) and a series of subroutines to perform the required calculations. Chart 1 shows the overall program flow, Chart 2 illustrates the input and initialization procedures, Chart 3 is a global description of the execution control. These program flow charts only provide a broad picture of the code. The interested user should consult the program listing about the details. Since the contour of the inlet varies from case to case according to user's interest, the user must set up the particular contour by slightly modifying the following subroutines: TIMGEO, INVICD and SPREAD.

In SUBROUTINE TIMGEO, the variables RBMAX and RBMIN must be specified by the user. RBMAX is the x-coordinate of the top wall at a given streamwise location and RBMIN is the x-coordinate of the bottom wall at the same streamwise location. In SUBROUTINE INVICD, the variable MZSHK must be given by the user. This variable indicates the initial location of the normal shock in the starting flow field, e.g., MZSHK = 10 means that at the 10th streamwise grid point a normal shock will be generated according to the Rankine-Hugoniot relation. Obviously, if the inflow is not supersonic and the

one-dimensional inviscid theory does not indicate an internal supersonic region, then MZSHK must be set to be an integer greater than the total number of streamwise grid points. In SUBROUTINE SPREAD, the variables PINVCD and HEIT must be specified by user. PINVCD is the dimensionless static pressure at the outflow section obtained by the one-dimensional inviscid theory under the condition that the dimensionless static pressure at the inflow section is 1. It should be noted that PINVCD may not be the actual static pressure used as boundary condition at the outflow section. HEIT is the height of the channel at the streamwise location denoted by KZ. Further, the variables MZSHK, PINVCD and HEIT are used only for setting up the starting flow field. The SUBROUTINE WRPLOT deals with the construction of plot files, since this also depends on the specific interest of the user, the coding of this subroutine must also be modified by the user to accommodate the user's interest. Nevertheless, since the structure of this subroutine is consistent with the NASA-Lewis inhouse plotting routines, the modifications should be quite straightforward.

The card input data is all in NAMELIST format: READ1, READ9, DATA1 and INFLW. The NAMELIST READ1 defines the restart option and input/output units. The NAMELIST READ9 specifies the grid parameters, reference quantities, time-step parameters, boundary conditions and print parameters. The NAMELIST DATA1 sets up the streamwise grid distribution, and the NAMELIST INFLW specifies the turbulent compressible boundary layer profiles at the inlet section. In the case of a restart run, the NAMELIST INFLW should not be supplied.

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```
                      ┌─────────────────────────┐
                      │           DAL           │
START ───────────────▶│  - - - - - - -          │
                      │     Main Program        │
                      └───────────┬─────────────┘
                                  │
                                  ▼
                      ┌─────────────────────────┐
                      │       Call READA        │
                      │  - - - - - - - - - -     │
                      │     Read Input and       │
                      │  Initialize Flow Field   │
                      └───────────┬─────────────┘
                                  │
                                  ▼
                      ┌─────────────────────────┐
                      │       Call EXEC         │
                      │  - - - - - - - - -       │
                      │   March Calculation      │
                      │     NT Time Steps        │
                      └───────────┬─────────────┘
                                  │
                                  ▼
                      ┌─────────────────────────┐
                      │      Call RESTRT        │
                      │  - - - - - - - - - -     │
                      │   Write Restart Files    │
                      └───────────┬─────────────┘
                                  │
                                  ▼
                      ┌─────────────────────────┐
                      │      Call PRNTF         │
                      │  - - - - - - - - - - -   │
                      │  Write Final Flow Field  │
                      └───────────┬─────────────┘
                                  │
                                  ▼
                          ╭───────────────╮
                          │     STOP      │
                          ╰───────────────╯
```
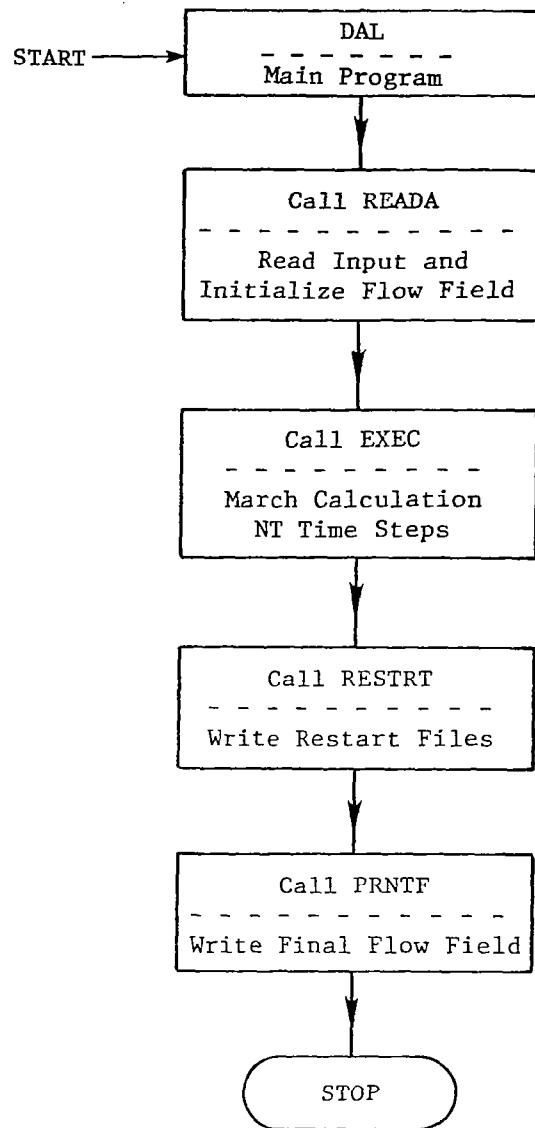
Chart 1. - Overall Program Flow, PROGRAM DAL

Called from DAL

Set Default Input

Call RDINP1(READ B)
- - - - - - - - - -
Read NAMELIST Input
from Cards and Restart
File 19

Set Integer
Variables and Flags

Call BVIV
- - - - - - - - -
Set Grid and
Initialize Flow Field

IREST≤ 0   Yes

No

Call RDIND2(READB)
READ FLOW Field from
Restart File 9

Return to DAL

Set Grid Parameters

Call COORD
- - - - - - - -
Set Geometry

No   IREST=0   Yes

Call FLWFLD
- - - - - - - - - - -
Initialize Flow Field

Zero Dependent
Variable Array

Do 1000
LZ=

Call SPREAD
- - - - - - - - - - -
Set Flow Field on
Line LZ

1000

Chart 2. - Program flow chart for SUBROUTINE READA

```
                                    ┌──────────────────────┐
        ┌──────────────────┐        │   Adjust Time Step   │
       (  Called from DAL  )         └──────────────────────┘
        └──────────────────┘                     │
                 │                               ▼
                 ▼                          ╱─────────╲      Yes
        ┌──────────────────┐              ╱     Is     ╲──────
        │    Call EXTBV    │             ╲  NT Reached? ╱
        │ ─ ─ ─ ─ ─ ─ ─ ─ ─│              ╲─────────────╱
        │ Set Boundary Values │                  │
        │    Zero Arrays   │                 No  │
        └──────────────────┘                     ▼
                 │                    ┌───┐   ┌─────────┐
                 ▼                    │ A │◄──│  1000   │
          ╱─────────╲   No            └───┘   └─────────┘
    No   ╱ IDUMP1=1  ╲──────                       │
   ◄────╲           ╱                              ▼
         ╲─────────╱                      ┌──────────────────┐
              │                          (  Return to DAL   )
          Yes │                           └──────────────────┘
              ▼
        ┌──────────────────┐
        │   Call PRNTA     │
        │ ─ ─ ─ ─ ─ ─ ─ ─  │
        │  Print Initial   │
        │  Flow Field      │
        └──────────────────┘
              │
              ▼
            ┌───┐
            │ 1 │
            └───┘
              │
              ▼
 ┌───┐   ╱─────────╲
 │ A │──▶╱ Do 1000  ╲
 └───┘   ╲  IDT=    ╱
          ╲─────────╱
              │
              ▼
     ┌──────────────┐      ┌──────────────┐
     │ Call TIMGEO  │─────▶│  Call ADIC   │
     │ ─ ─ ─ ─ ─ ─  │      │ ─ ─ ─ ─ ─ ─  │
     │ Set Geometry │      │    Solve     │
     │              │      │  Equations   │
     └──────────────┘      └──────────────┘
              │
              ▼
     ┌──────────────────┐
     │   Call PRNTS     │
     │ ─ ─ ─ ─ ─ ─ ─ ─  │
     │     Print        │
     │ Intermediate Output │
     └──────────────────┘
```
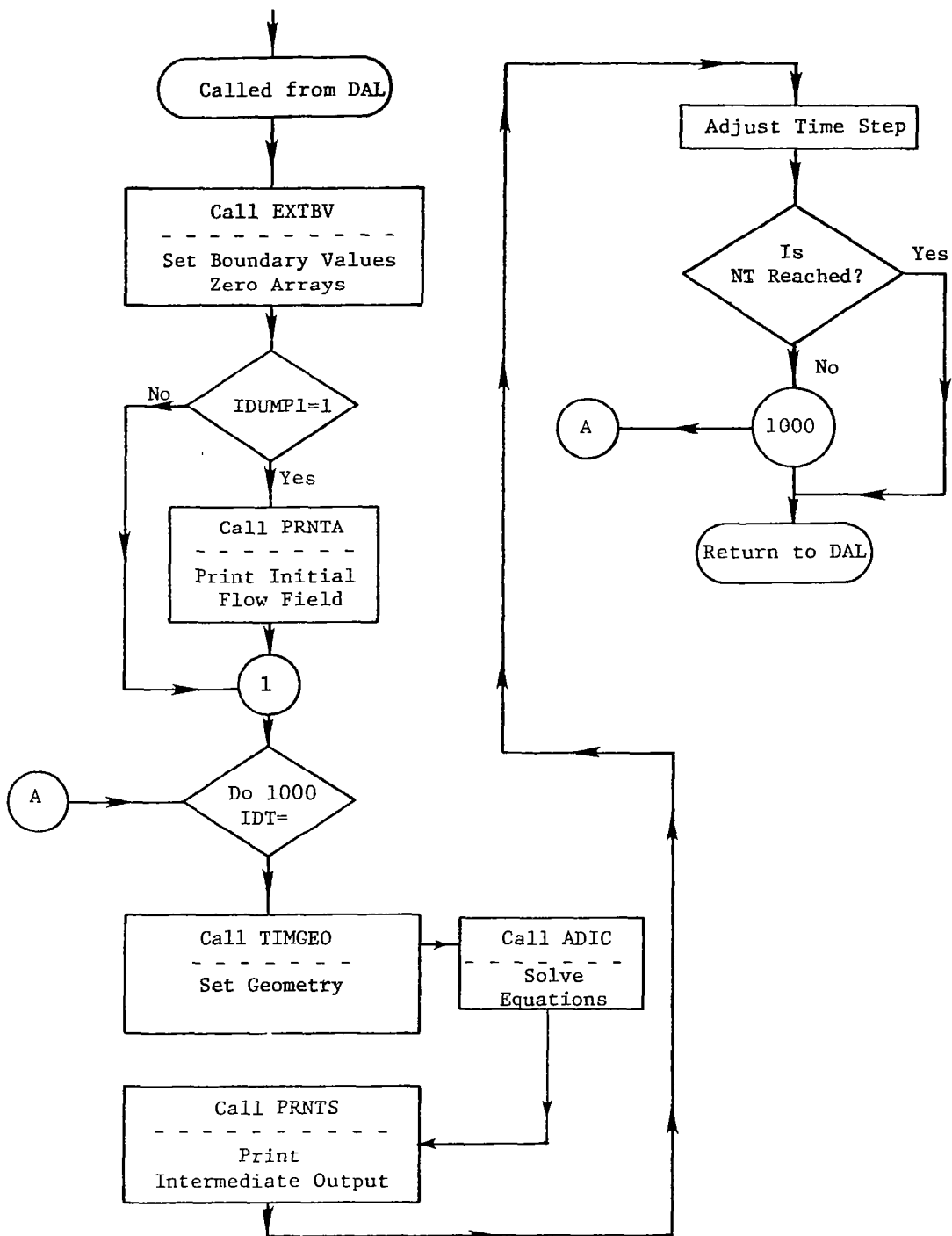
Chart 3. – Program flow chart for SUBROUTINE EXEC

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NAMELIST INPUT Description

Namelist or Variable Name		Description
&READ1		
IREST	= 0	A new calculation is being started.
	= 1	Case is being run from restart files.
IOTAPE	=10	Output unit number for dependent variable array restart data.
INTAPE	= 9	Input unit number for dependent variable array restart data.
IOTAP1	=20	Output unit number for namelist restart data.
INTAP1	=19	Input unit number for namelist restart data.
&READ9		
NUMDX		Number of interior grid points in the transverse direction (x or y^1 direction). Total number of points in this direction = NUMDX + 2. NUMDX $\leq$ 29.
NUMDY		Number of interior grid points in the spanwise direction (y or y^2 direction). Total number of points in this direction = NUMDY + 2. NUMDY $\leq$ 29.

Namelist or Variable Name	Description
NUMDZ	Number of interior grid points in the streamwise direction (z or y^3 direction). Total number of points in this direction = NUMDZ + 2. NUMDZ $\leq$ 59.
XGMIN(1)	Dimensionless value of x-coordinate of the bottom wall at the inflow boundary.
XGMIN(2)	Dimensionless value of y-coordinate of the side wall.
XGIMIN(3)	Dimensionless value of z-coordinate at the inflow boundary.
XGMAX(1)	Dimensionless value of x-coordinate of the top wall at the inflow boundary.
XGMAX(2)	Dimensionless value of y-coordinate of the (spanwise) symmetry plane.
XGMAX(3)	Dimensionless value of z-coordinate of the outflow boundary.
GRID(I), I = 1-6	Define $\tau_1 \equiv$ GRID(2K-1) $\tau_2 \equiv$ GRID(2K) For each coordinate direction y^k (K=1,2,3). τ_1 and τ_2 are the grid stretching parameters for controlling grid spacing near the computational domain boundaries. In the present code this grid distribution technique is used for the x and y directions. The streamwise, z-direction, is constructed via variables in &DATA1. The limits on τ_1 and τ_2 are: $-1 < \tau_1 \leq 0$, $0 \leq \tau_2 < 1$. If $\tau_1 = \tau_2 = 0$, the grid spacing is uniform. If $\tau_1 = 0$, $\tau_2 > 0$, the grid points will be more dense near the XGMAX(K) boundary. If $\tau_1 < 0$, $\tau_2 = 0$, the grid points will be more dense near the XGMIN(K) boundary. The transformation is singular if $\tau_1 = -1$ or $\tau_2 = 1$.

Namelist or Variable Name		Description
XCENTR(I), I=1-3.	= 0	Not used.
DAMPG(I), I=1-3.	= 0	Not used.
IGEOM	= 1	The height of the channel is not a function of streamwise coordinate.
	= 2	Contoured channel.
TWOD	= T	Logical variable for two-dimensional calculation.
	= F	Logical variable for three-dimensional calculation.
IGTYPE	= 1	Two-dimensional calculation. Used with TWOD = T
	= 2	Three-Dimensional calculation. Used with TWOD = F
LXSPLT		x grid point location for summary print.
LYSPLT		y grid point location for summary print. Default is 1.
REY		Reynolds number (calculated).
CLENG		Reference length, meters (throat height).
WREF		Reference velocity, m/sec (core-flow velocity at the inflow boundary).

Namelist or Variable Name	Description
DENSR	Reference density, kg/m^3 (core-flow density at the inflow boundary).
TREF	Reference temperature, °K (core-flow temperature at the inflow boundary).
PREF	Reference pressure, Pa (calculated).
VISCR	Reference dynamic viscosity, kg/m-sec (core-flow dynamic viscosity at the inflow boundary).
CMACH	Reference Mach Number (calculated)
LAMFLO = 0	Turbulent flow
≠ 0	Obsolete.
AVISC(IDIR,IEQ)	Artificial dissipation parameter σ (See Eq. (1) of the Appendix). IEQ = 1-5, and IDIR=1-3. IEQ = 1 indicates the x-momentum equation. IEQ = 2 indicates the y-momentum equation. IEQ = 3 indicates the z-momentum equation. IEQ = 4 indicates the continuity equation. IEQ = 5 indicates the energy equation. IDIR=1 indicates the x second derivative term IDIR=2 indicates the y second derivative term IDIR=3 indicates the z second derivative term

For example, AVISC(3, 1) is the value of σ used for the artificial dissipation term $\frac{\partial^2 U}{\partial z^2}$ in the x-momentum equation. Note that even if the y-momentum equation is not solved, the corresponding AVISC must be supplied. Default values are 0.0. Recommended values are 0.50 initially followed by runs at 0.10. |

Namelist or Variable Name		Description
NT		Number of time steps to be run
DT		Initial nondimensional time step. If DT is omitted on a restart DT will be set to value at termination of last run.
DTMIN		Minimum nondimensional time step for this run
DTMAX		Maximum nondimensional time step for this run
IDTADJ	= 0	Constant DT is used for this run
	= 1	Time step adjusted. If maximum relative change in any flow variable is less than 0.04, DT is multiplied by 1.25. If maximum relative change in any flow variable is greater than 0.06, DT is divided by 1.25.
	= 2	Time step is cycled between DTMIN and DTMAX using an acceleration parameter concept. A sequence of NTSTEP time steps is used under this option.
NTSTEP		Number of time steps used in cycling. Default value is 3.
ITEST		Steady state test is performed every ITEST time steps. Default value is 1.
SSEPS		Steady-state convergence criteria. Default is 0.001.
IPRINT		Complete flow field printouts are provided every IPRINT time steps.

Namelist or Variable Name		Description
LZPRNT(LZ)		Optional print control flag for three-dimensional calculations only.
	= 0	No printout at streamwise station number LZ
	= 1	Normal printout at Station LZ. Default is 1.
IVARPR(IV)		Optional print control flag for variable IV
	= 0	Suppress printout of variable IV
	= 1	Normal printout of variable IV

IV	IVARPR(IV)
1	transverse velocity, u
2	spanwise velocity, v
3	streamwise velocity, w
4	density, ρ
5	enthalpy, h
26	pressure, p
27	temperature, T
28	effective viscosity, μ_{eff}
33	mixing length, ℓ
35	Mach number, M
36	total pressure, Po

IDUMP1		
	= 1	Print initial flow field for this run.
	= 2	No initial printout.
IPLOT		
	= 0	No plot file (TAPE1) written.
	> 0	Plot file written at time step increment IPLOT.
NFPLOT		
	= 0	NFPLOT must be set to zero.

Namelist or Variable Name		Description
IGPRT(1)	= 0	No x-coordinate printout.
	= 1	Print x-coordinate distribution.
IGPRT(2)	= 0	No y-coordinate printout.
	= 1	Print y-coordinate distribution. Default is 0.
IGPRT(3)	= 0	No z-coordinate printout.
	= 1	Print z-coordinate distribution.
ICASE	= 1	Inflow is not supersonic.
	= 2	Inflow is supersonic.
PRESS6		Dimensionless static pressure at the outflow section. Note that the reference condition is the inflow core condition.
&DATA1		
YFIRST	= XGMIN(3)	See &READ9.
YLAST	= XGMAX(3)	See &READ9.
NCLUST		Total number of the interior cluster points. A cluster point is the sequential number of the selected grid point which must coincide with particular predetermined value of the z-coordinate. Accordingly, pairs of (1, YFIRST) and (NUMDZ+2, YLAST) are also cluster points, but they are boundary cluster points.

Namelist or Variable Name		Description
CLPY(I), I=1-61		The z-coordinate of the cluster point. Note that both of boundary and internal cluster points must be specified.
CLPX(I), I=1-61		The sequential number of the grid point corresponding to CLPY(I).
ETAP(J), J=1-61		The sequential number of the grid point defined as pivot point. The grid spacing will have the fastest variation at a pivot point. For each of the interior cluster points there shall be a pair of pivot points: one ahead of the cluster point, the other one after the cluster point. However, only one pivot point shall be associated with each of the boundary cluster points.
ALPH(J), J=1-61		Width parameter specifying width (in terms of the number of grid points) in which 90 per cent of grid-size variation takes place around the pivot point ETAP(J).
	> 0	decreasing grid-size.
	< 0	increasing grid-size.
NEND	= 0	No stretching at YFIRST and YLAST
	= 1	Stretching at YFIRST only
	= 2	Stretching at YLAST only
	= 3	Stretching at YFIRST and YLAST
RHW	always > 0.0	Approximate ratio of grid-size at CLPY(2) to the maximum grid-size in the interval CLPY(1) <Z< CLPY(2).
	= 1.0	No stretching at YFIRST. Used with NEND = 0 or 2.

Namelist or Variable Name	Description
RATIO(K), K = 1-40. always > 0.0	Approximate ratio of grid-size at CLPY(K+1) to the maximum grid-size in the interval CLPY(K) <Z< CLPY(K+1)
= 1.0	No grid-variation at CLPY(K+1).
BETAO always > 0.0	Calculated. It indicates the first derivative of Z-coordinate with respect to the computational coordinate at YFIRST.
BET(L), L = 1-61. alwyas > 0.0	Calculated. It indicates the ratio between the grid sizes on both sides of the pivot point ETAP(L+1).
&INFLW	
CFLW	Coefficient of skin friction at the botton wall of inflow boundary.
DELTAL	Dimensionless boundary layer thickness at the bottom wall of inflow boundary.
PRDL	Prandtl Numer used only for generating the bottom wall velocity profile.
CFUW	Coefficient of skin friction at the top wall of inflow boundary.
DELTAU	Dimensionless boundary layer thickness at the top wall of inflow boundary.
PRDU	Prandtl Number used only for generating the top wall velocity profile.
TINF = TREF	See &READ9

LIST OF MAJOR FORTRAN VARIABLES

FORTRAN SYMBOL	COMMON BLOCK	DESCRIPTION
AC(I,J,K)	BLK1	DEPENDENT VARIABLE ARRAY
ACG(J,J)	BLK1	GEOMETRY DATA ARRAY
AN(I,J)	BLKM	ARRAY STORING TIME TERM LINEARIZED COEFFICIENTS
APR(I,J)	PRNT	PRINT OUTPUT ARRAY
AVANDR	TURB	DAMPING CONSTANT
AVISC(I,J)	MISC2	ARTIFICIAL DISSIPATION PARAMETER
C(I,J,K)	BLKM	COUPLED MATRIX ARRAY STORAGE
CLENG	CREF	REFERENCE LENGTH
CMACH	MISC2	REFERENCE MACH NUMBER
D	VARNO	INDEX FOR DIVERGENCE
D1(I,J,K)	BLKM	ARRAY STORING FIRST SWEEP LINEARIZED COEFFICIENTS
D2(I,J,K)	BLKM	ARRAY STORING SECOND SWEEP LINEARIZED COEFFICIENTS
D3(I,J,K)	BLKM	ARRAY STORING THIRD SWEEP LINEARIZED COEFFICIENTS
DENSR	CREF	REFERENCE DENSITY
DFW(I,J,K)	ADI7	DIFFERENCE WEIGHT ARRAY
DIM1	NOND	INVERSE REYNOLDS NUMBER
DIM2	NOND	REFERENCE PRESSURE/REFERENCE DYNAMIC HEAD
DIM3	NOND	REFERENCE PRESSURE/(REFERENCE DENSITY * REFERENCE ENTHALPY)
DIM4	NOND	$1.0/(REY * P_r)$
DIM12	NOND	$2.0 * DIM1$
DS	VARNO	INDEX FOR DISSIPATION
DT	MISC2	TIME STEP

FORTRAN SYMBOL	COMMON BLOCK	DESCRIPTION
DTCON	MISC2	INVERSE STEP
DTMAX	MISC2	MAXIMUM ALLOWABLE TIME STEP
DTMIN	MISC2	MINIMUM ALLOWABLE TIME STEP
E(I,J,K)	BLKM	COUPLED MATRIX ARRAY STORAGE
GRID(I)	GTRAN	GRID DISTRIBUTION PARAMETER (SEE &READ9)
H	VARNO	INDEX FOR ENTHALPY
I1	MGAUS	LOWER LIMIT FOR MATRIX INVERSION
IADI	ADI1	ADI SWEEP NUMBER
IBC	ADI1	BOUNDARY CONDITION BOUNDARY PARAMETER
IDT	MISC2	TIME STEP INDEX
IDTADJ	MISC2	TIME STEP CONTROL PARAMETER (SEE &READ9)
IDUMP1	OUTA	PARAMETER CONTROLLING INITIAL STATION PRINT (SEE &READ9)
IEQ	ADI1	EQUATION NUMBER
IGPRT(I)	GEO1	GEOMETRY PRINT CONTROL (SEE &READ9)
IL	MGAUS	UPPER LIMIT FOR MATRIX INVERSION
IPRINT	MISC2	PRINT INTERVAL PARAMETER (SEE &READ9)
IRERUN	MISC2	RESTART WRITE CONTROL PARAMETER (SEE&READ1)
IREST	MISC2	RESTART READ CONTROL PARAMETER (SEE &READ1)
IVARPR(I)	MISC2	PRINT PARAMETER (SEE &READ9)
JADI	ADI1	ADI SWEEP PARAMETER
JEQBC(I,J,K)	ADI1	BOUNDARY CONDITION TYPE PARAMETER
JX	ADI2	DIRECTION-1 GRID POINT INDEX
KZ	ADI2	DIRECTION-3 GRID POINT INDEX

FORTRAN SYMBOL	COMMON BLOCK	DESCRIPTION
LX	ADI2	DIRECTION-1 GRID POINT INDEX
LX1	ADI3	FIRST DIRECTION-1 INTERIOR POINT
LX2	ADI3	LAST DIRECTION-1 INTERIOR POINT
LY	ADI2	DIRECTION-2 GRID POINT INDEX
LY1	ADI3	FIRST DIRECTION-2 INTERIOR POINT
LY2	ADI3	LAST DIRECTION-2 INTERIOR POINT
LZ	ADI2	DIRECTION-3 GRID POINT INDEX
LZ1	ADI3	FIRST DIRECTION-3 INTERIOR POINT
LZ2	ADI3	LAST DIRECTION-3 INTERIOR POINT
LZPRNT	MISC2	THREE DIMENSIONAL PRINT CONTROL (SEE &READ9)
MEQS	ADI1	NUMBER OF EQUATIONS TO BE SOLVED
NT	MISC2	NUMBER OF TIME STEPS TO BE RUN
NUMDX	MISC2	NUMBER OF INTERIOR DIRECTION-1 POINTS
NUMDY	MISC2	NUMBER OF INTERIOR DIRECTION-2 POINTS
NUMDZ	MISC2	NUMBER OF INTERIOR DIRECTION-3 POINTS
NX1	ADI4	FIRST GRID POINT - DIRECTION 1
NX2	ADI4	LAST GRID POINT - DIRECTION 1
NY1	ADI4	FIRST GRID POINT - DIRECTION 2
NY2	ADI4	LAST GRID POINT - DIRECTION 2
NZ1	ADI4	FIRST GRID POINT - DIRECTION 3
NZ2	ADI4	LAST GRID POINT - DIRECTION 3

FORTRAN SYMBOL	COMMON BLOCK	DESCRIPTION
P	VARNO	INDEX FOR PRESSURE
PCNT1	MISC2	TIME STEP CONTROL PARAMETER
PCNT2	MISC2	TIME STEP CONTROL PARAMETER
PREF	CREF	REFERENCE PRESSURE
PRNDL	CREF	PRANDTL NUMBER
PTOT	BCCON	TOTAL PRESSURE
R	VARNO	INDEX FOR DENSITY
REY	CREF	REYNOLDS NUMBER
SN(I)	BLKM	ARRAY STORING SOURCE TERM LINEARIZED COEFFICIENT
SSTEST	MISC2	MAXIMUM CHANGE IN VARIABLE ACROSS TIME STEP
T	VARNO	INDEX FOR TEMPERATURE
TAUW	TURB	WALL SHEAR
TREF	CREF	REFERENCE TEMPERATURE
TTIME	MISC2	CUMULATIVE TIME
TTOT	BCCON	TOTAL TEMPERATURE
U	VARNO	INDEX FOR DIRECTION-1 VELOCITY
USTAR	TURB	DIMENSIONLESS VELOCITY
V	VARNO	INDEX FOR DIRECTION-2 VELOCITY
VISCL	TURB	LAMINAR REFERENCE VISCOSITY
VISCR	CREF	REFERENCE VISCOSITY
VS	VARNO	INDEX FOR VISCOSITY

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FORTRAN SYMBOL	COMMON BLOCK	DESCRIPTION
W	VARNO	INDEX FOR DIRECTION-3 VELOCITY
WREF	CREF	REFERENCE VELOCITY
XGMAX(I)	GRID1	MAXIMUM COORDINATE VALUE (SEE &READ9)
XGMIN(I)	GRID1	MINIMUM COORDINATE VALUE (SEE &READ9)
YPLUS	TURB	DIMENSIONLESS DISTANCE FROM SURFACE

FILE INPUT/OUTPUT

To read restart files, the following commands must be given at the beginning
of a run:

```
RMDS      A10, R9
RELEASE RMDS
RMDS      A20, R19
RELEASE RMDS
```

To write restart files, the following command must be given at the end of a run:

```
CATALOG SC10, U,, A10
MDS A10
CATALOG SC20, U,, A20
MDS A20
```

Where A10 and A20 are some given file names, SC10 and SC20 are scratch files
defined in PROCDEF RUNMT.

Remarks on Storage Requirements and Run Time

When stored in data pool of the Lewis IBM 370, the files INLTS, INLTB and INLTCM
(see page 83) occupy 171, 476 and 10 pages, respectively. The sizes of the
restart files are problem dependent; as an example, for 2-D problems with
31 x 41 grid points, the file A10 requires 78 pages and the file A20 requires
2 pages. For 3-D problems with 31 x 41 x 16 grid points, the file A10 requires
640 pages, while the file A20 needs 3 pages. As for the run time, in terms of
CPU sec per time-step per grid-point, approximately 0.013 sec is needed in a
2-D problem and 0.028 sec is required for a 3-D problem.

As a further indication of the storage requirements, information obtained from
executing another version of the MINT Code on a CDC machine is also given here.
With 3500 grid points, 225000 decimal words are needed; however, by using
overlay and out-of-core-option, the storage requirement has been reduced to
90000 decimal words. Although this out-of-core-option is not included in the
present INLTS.G01 version, the implementation of this option can be carried
out in a straightforward manner.

```
PROCDEF MOD
PARAM $A
DDEF X,VI,SOURCE.$AN,RET=T
DEFAULT SYSINX=E
EDIT SOURCE.$AN
-REVISE 100,LAST
-EXCERPT M,$A,100,LAST


PROCDEF MODN
PARAM $A
-END
FIN $AN,LISTDS=N,SLIST=N,CRLIST=N
DEFAULT SYSINX=G
ERASE SOURCE.$AN



PROCDEF RUNMT
ERASE M
DDEF FT01F001,VS,SC01,RET=T
DDEF FT02F001,VS,SC02,RET=T
DDEF FT03F001,VS,SC03,RET=T
DDEF FT04F001,VS,SC04,RET=T
DDEF FT09F001,VS,R9,RET=T
DDEF FT10F001,VS,SC10,RET=T
DDEF FT11F001,VS,SC11,RET=T
DDEF FT12F001,VS,SC12,RET=T
DDEF FT13F001,VS,SC13,RET=T
DDEF FT14F001,VS,SC14,RET=T
DDEF FT15F001,VS,SC15,RET=T
DDEF FT16F001,VS,SC16,RET=T
DDEF FT17F001,VS,SC17,RET=T
DDEF FT19F001,VS,R19,RET=T
DDEF FT20F001,VS,SC20,RET=T
DDEF FT21F001,VS,SC21,RET=T
LOAD BLKDATN
LOAD DALN
DALN
```

Sample Input Cards and Printed Output

A sample case was run to illustrate the set up of input parameters and typical printouts of the INLTS.GO1 code. The given input card deck is for a new calculation. In the case of restarted calculation, all parameters of &READ1 and &DATA1 must be specified, however, in &READ9, only NT, PRESS6 and ICASE must always be specified through input cards for restarted calculation, unless the user wants to change other parameters for other purposes. The Namelist &INFLW should be omitted for restarted calculation. Also note that, parameters associated with the grid point distribution should not be changed since the computational coordinate system is time-independent.

The code output first prints out a series of dimensionless parameters DIM1 - DIM10, DIM12 and DIM14, and the dimensionless total temperature, total pressure and total enthalpy. This is followed by the finite difference coefficients for first and second derivatives in both directions. In each direction three lines are written. The first and third lines give one-sided difference weights at the lower and upper boundaries; the second line of each set gives central differences used for the interior points. Six numbers are written on each line; the first set of three values represent the first derivative coefficients and the second set of three values represent the second derivative coefficients.

The next output item is the grid distribution data. They are quite self-explanatory. The first part indicates the results of streamwise coordinate transformation (see SUBROUTINES OHGRID, STCLST and FIXBY1). The second part gives the x-coordinates at each z location and the third part gives the z-coordinates of each streamwise grid point.

These geometry data are followed by the printout of NAMELIST INFLW and the results of the inflow boundary layer profiles calculation. These are printed out in the SUBROUTINE PROFIL, the user should consult this subroutine if detailed informations are desired. It is only noted here that the first part deals with the bottom wall boundary layer profile calculation and the second part deals with the top wall boundary layer profile calculation.

Following the boundary layer profiles printouts, the results of one-dimensional inviscid calculation are printed in the SUBROUTINE INVICD. The inviscid solutions are given at each streamwise grid point. The SUBROUTINES INVICD and SPREAD should be consulted about these results. The following item is the printouts of the NAMELISTS READ1, READ9 and DATA1. Note that values of some parameters may be changed by the internal operations.

The output of the namelist data is followed by estimations of the total mass and total energy within the computational domain, as well as the estimated mass flux at each streamwise section. This is then followed by the printouts of the flowfield variables at the starting time-step of this calculation. These printouts are quite self-explanatory and will not be described in detail here. At each time-step, a summary print is written, in which the maximum relative change over a time-step is given by SSTEST along with the location. Also given are the maximum relative changes of each dependent variable. RESMAX is the maximum residual of the equations solved and indicates how well is the steady-state equation being satisfied. Finally, flow variables at (LXSPLT, LYSPLT) are written for each streamwise station. Note that PBOT, PTOP and DP represent static pressure at the bottom wall, top wall,and at the point indicated by LXSPLT. A typical set of output along with the corresponding given input will be presented in the following pages.

Note that the JOB CONTROL LANGUAGE (JCL) streams, as presented in pages 81 and 82, are for the IBM 370 and the command DDEF defines devices which must be assigned for any other type machine. Also note that all the level 1 errors appearing in pages 83 and 84 are due to the non-optimal arrangements of the common blocks involved in the subroutines and they do not adversely affect execution of the code.

```
   LOGON P          ,,,90
ERASE R9
ERASE R19
ERASE MINT
ERASE PROCM
ERASE M
RMDS INLTB,MINT
RELEASE RMDS
DDEF XXX,VP,DSNAME=MINT,OPTION=JOBLIB,DISP=OLD
RMDS INLTS,M
RELEASE RMDS
RMDS INLTCM,PROCM
RELEASE RMDS
MOD SPREAD
_REVISE 54300
        PINVCD=1.0
_MODN SPREAD
RUNMT
 &READ1
 IREST = 0,
 IOTAPE=10,
 INTAPE=9,
 IOTAP1=20,
 INTAP1=19,
 &END READ1
 &READ9
 NT=3,
 ICASE=1,
 PRESS6=0.993,
 NUMDX=18,NUMDZ=18,
 XGMIN=0.0,0.0,0.0,
 XGMAX=1.0,0.0,2.0,
 GRID=-0.9995,0.9995,4*0.0,
 XCENTR(1) = 0.0, 0.0, 0.0,
 DAMPG=0.0,0.0,0.0,
 IGEOM = 1,
 TWOD = T,  IGTYPE=1,
 LXSPLT=10,
 CLENG =0.0441,
 WREF =149.17675,
 DENSR = 1.2692128,
 TREF = 287.623,
 VISCR = 1.7641588D-05,
 LAMFLO=0,
 AVISC(1,1)=15*0.5,
 DT=0.005,DTMIN=0.001,DTMAX=0.10,
 IDIADJ = 1,
 ITEST = 1,
 IPRINT=10,
 IVARPR = 28*1,
 IVARPR(29) = 0,
 IVARPR(33) = 1,      IVARPR(35) = 1,
 IDUMP1= 1,
 IPLOT=0,
 IGPRT=1,0,1,
 &END READ9
```

```
&DATA1
NCLUST=0,
NEND=0,
BETA0=0.0,
ETAP=2.0,20.0,
ALPH=1.0,1.0,
YFIRST=0.0,
YLAST=2.0,
CLPX=1.0,20.0,
CLPY=0.0,2.0,
RATIO=1.0,
BET=3*0.0,
RHW=1.0,
&END DATA1
$INFLW
CFLW=0.00166,
DELTAL=0.12149,
PROL=1.0,
CFUW=0.00156,
DELTAU=0.12149,
PROU=1.0,
TINF=287.623,
&END INFLW
RELEASE FT
ERASE R9
ERASE R19
ERASE MINT
ERASE PROCM
ERASE M
ERASE SC01
ERASE SC10
ERASE SC20
   LOGOFF
```

```
P    ...90
ISS/370 RELEASE 3.0 PRPU2 PTF15
---> CLEAN UP LRDAT... <---    RSN=2755    PUGLID=LRCFM    LOGON AT 15:07 ON 11/10/82.
ERASE R9
0512        CANCELLED: R9 UNKNOWN.
ERASE R19
0512        CANCELLED: R19 UNKNOWN.
ERASE MINT
0512        CANCELLED: MINT UNKNOWN.
ERASE PROCM
0512        CANCELLED: PROCM UNKNOWN.
ERASE M
0512        CANCELLED: M UNKNOWN.
RMDS INLTH.MINT
CZA92527    SUCCESSFUL (TEMP) RESTORE INLTH AS (MINT)
RELEASE RMDS
DDEF XXX.VP.DSNAME=MINT.OPTION=JOBLIB.DISP=OLD
RMDS INLTS.M
CZA92527    SUCCESSFUL (TEMP) RESTORE INLTS AS (M)
RELEASE RMDS
RMDS INLTCM.PROCM
CZA92527    SUCCESSFUL (TEMP) RESTORE INLTCM AS (PROCM)
RELEASE RMDS
MOD SPREAD
_REVISE 54300
0054300        PINVCD=1.0
_MODN SPREAD
ISPREADN .11/10/82 15:10:52
ISPREADN .11/10/82 15:10:52
CFAUAD17    MINOR ERRORS
RUNNI
CZCDLO05    PROCEEDING: MODULE RLKDATN    PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE DALN      PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE EXECN     PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE ADICN     PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE ADICXN    PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE ADICPIN   PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE DUPN      PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE GENEO2N   PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE DIFFN     PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE EDSN      PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE NCCHFMN   PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE GASPN     PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE MINMAXN   PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE EXTENTN   PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE DELUN     PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE SURCHN    PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE RADEQNN   PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE CURVTN    PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE CONVCTN   PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE ARTVISN   PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE GENEO3N   PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE GENRCN    PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE RCN       PRODUCED WITH LEVEL 1 ERRORS
CZCDLO03    UNDEFINED REF ALFA      IN MODULE RCN    . ADDRESS FFFFF000 ASSIGNED
CZCDLO05    PROCEEDING: MODULE RCPMN     PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE ATIMEN    PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE SOURCEN   PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE TCMUN     PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE RATCH4N   PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE RNOXN     PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE SORAUXN   PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE FPORTN    PRODUCED WITH LEVEL 1 ERRORS
CZCDLO03    UNDEFINED REF IPOR1     IN MODULE FPORTN  . ADDRESS FFFFF000 ASSIGNED
CZCDLO03    UNDEFINED REF IPOR2     IN MODULE FPORTN  . ADDRESS FFFFF000 ASSIGNED
CZCDLO03    UNDEFINED REF LCPORT    IN MODULE FPORTN  . ADDRESS FFFFF000 ASSIGNED
CZCDLO05    PROCEEDING: MODULE USTARN    PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE WALLFN    PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE MGAUSFN   PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE QUICKN    PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE MGERRN    PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE WRMATRN   PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE WRDISKN   PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE MATRTN    PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE AMATRXN   PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE MGAUSPN   PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE MSUBTN    PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE WMULTN    PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE FINVRSN   PRODUCED WITH LEVEL 1 ERRORS
CZCDLO05    PROCEEDING: MODULE MINVRSN   PRODUCED WITH LEVEL 1 ERRORS
```

```
CZCOL005     PROCEEDING: MODULE ADIUNIN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE GENORCN  PRODUCED WITH LEVEL 1 ERRORS
1CZCOL005    PROCEEDING: MODULE GAUSSN   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE DOUBLEN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE PRINTIN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE WRSLABN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE ADICYN   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE ADICP2N  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE ADIUN2N  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE ADICZIN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE ADICZON  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE ROTATEN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE EXTBVN . PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE DIVN     PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE DISFCNN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE TMEN     PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE LOADACN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE MAXPN    PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE SETBVN   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE LINCORN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE TEMPNN   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE MFNOXN   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE MAXUEHN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE TEMPSN   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE TERMSN   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE PROJCTN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE VISCOSN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE MIXLENN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE CRJETN   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE MIXL3DN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE SETOKEN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE SETBVIN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE VTWALLN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE WALLVSN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE SSISTN   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE HTFLUXN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE EXITPRN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE PRNTAN   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE RESULTN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE TPLOTN   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE TIMGEON  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE EVALIN   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE MNFITN   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE PRGEON   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE WRPLOTN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE READAN   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE BVIVN    PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE FLW3DN   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE PROFILN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE COORDN   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE INTGEON  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE FLWFLUN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE SPREADN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL003     UNDEFINED REF IPOR1    IN MODULE SPREADN . ADDRESS FFFFF000 ASSIGNED
CZCOL003     UNDEFINED REF IPOR2    IN MODULE SPREADN . ADDRESS FFFFF000 ASSIGNED
CZCOL005     PROCEEDING: MODULE INTDATN  PRODUCED WITH LEVEL 1 ERRORS
1CZCOL003    UNDEFINED REF LCPORT   IN MODULE SPREADN . ADDRESS FFFFF000 ASSIGNED
CZCOL005     PROCEEDING: MODULE CORNERN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE LOCEON   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE READBN   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE ROLISTN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE NORMDN   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE OPENMSN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE INTERPN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE REZONEN  PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE CHOXIN   PRODUCED WITH LEVEL 1 ERRORS
CZCOL005     PROCEEDING: MODULE RESTRTN  PRODUCED WITH LEVEL 1 ERRORS
```

```
********    MINT INLET CODE    *******

0INITIAL INPUT STREAM

0RESTART OUTPUT UNIT TP20   POSITIONED AT RESTART DUMP  NO.  0      0 PARTITIONS SKIPPED.

0RESTART OUTPUT UNIT TP10   POSITIONED AT RESTART DUMP  NO.  0      0 PARTITIONS SKIPPED.

  DIM1-DIM10,DIM12,DIM14
   2.1128E-06 3.7099E 00 2.8567E-01 2.8943E-06 7.7001E-02 1.6269E-07 2.2286E-07 2.8943E-06 1.0000E 00 7.0915E-06 4.2256E-06      0.000
 0T, P, H-TOTAL = 1.03850E 00 1.14139E 00 1.03850E 00
```

0DIRECTION-1 DIFFERENCE OPERATORS

```
    1  -1.50000000E 00 2.00000000E 00-5.00000000E-01      1.00000000E 00-2.00000000E 00 1.00000000E 00
    2  -5.00000000E-01     0.00000000 5.00000000E-01      1.00000000E 00-2.00000000E 00 1.00000000E 00
    3   5.00000000E-01-2.00000000E 00 1.50000000E 00      1.00000000E 00-2.00000000E 00 1.00000000E 00
```

0DIRECTION-3 DIFFERENCE OPERATORS

```
    1  -1.50000000E 00 2.00000000E 00-5.00000000E-01      1.00000000E 00-2.00000000E 00 1.00000000E 00
    2  -5.00000000E-01     0.00000000 5.00000000E-01      1.00000000E 00-2.00000000E 00 1.00000000E 00
    3   5.00000000E-01-2.00000000E 00 1.50000000E 00      1.00000000E 00-2.00000000E 00 1.00000000E 00
```
0FIRST AND LAST TRANSFORMED AND PHYSICAL COORDS
0TRANSFORMED COORDINATE RANGE- XFIRST=   1.0000000000 XLAST=   20.0000000000
0 PHYSICAL COORDINATE RANGE- XFIRST=   0.0000000000XLAST=   2.0000000000
0   N/. OF GRID POINTS=   20
                         NO. OF PIVOTS   =   0
                         BASE SLOPE   =   0.0000000000

```
    I     X            Y          RATIO
    1  20.000000     2.000000    1.000000
    I    ETA         ALPHA
    1   2.000000     1.000000
    2  20.000000     1.000000
 BETA0=         0.105263158
```
```
0   I          ETA                ALPHA                 BETA
    1      2.000000000        1.000000000        0.000000000
0        X            Y            Z            DER          DELZ
    1   1.000000000  0.000000000  0.000000000  0.105263158  0.105263158
    2   2.000000000  0.105263158  0.105263158  0.105263158  0.105263158
    3   3.000000000  0.210526316  0.210526316  0.105263158  0.105263158
    4   4.000000000  0.315789474  0.315789474  0.105263158  0.105263158
    5   5.000000000  0.421052632  0.421052632  0.105263158  0.105263158
    6   6.000000000  0.526315789  0.526315789  0.105263158  0.105263158
    7   7.000000000  0.631578947  0.631578947  0.105263158  0.105263158
    8   8.000000000  0.736842105  0.736842105  0.105263158  0.105263158
    9   9.000000000  0.842105263  0.842105263  0.105263158  0.105263158
   10  10.000000000  0.947368421  0.947368421  0.105263158  0.105263158
   11  11.000000000  1.052631579  1.052631579  0.105263158  0.105263158
   12  12.000000000  1.157894737  1.157894737  0.105263158  0.105263158
   13  13.000000000  1.263157895  1.263157895  0.105263158  0.105263158
   14  14.000000000  1.368421053  1.368421053  0.105263158  0.105263158
   15  15.000000000  1.473684211  1.473684211  0.105263158  0.105263158
   16  16.000000000  1.578947368  1.578947368  0.105263158  0.105263158
   17  17.000000000  1.684210526  1.684210526  0.105263158  0.105263158
   18  18.000000000  1.789473684  1.789473684  0.105263158  0.105263158
   19  19.000000000  1.894736842  1.894736842  0.105263158  0.105263158
   20  20.000000000  2.000000000  2.000000000  0.105263158  0.105263158
1
```
0GEOMETRY DATA AT TSTEP NO.   0   GTIME =   0.00000000

0***** X1-COORD-FIX *****

```
0LZ=        1         2         3         4         5         6         7         8         9        10
  Z=   0.0000000.105263E 000.210526E 000.315789E 000.421053E 000.526316E 000.631579E 000.736842E 000.842105E 000.947368E 00

  20   0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01
  19   0.99965E 00 0.99965E 00 0.99965E 00 0.99965E 00 0.99965E 00 0.99965E 00 0.99965E 00 0.99965E 00 0.99965E 00 0.99965E 00
  18   0.99882E 00 0.99882E 00 0.99882E 00 0.99882E 00 0.99882E 00 0.99882E 00 0.99882E 00 0.99882E 00 0.99882E 00 0.99882E 00
  17   0.99683E 00 0.99683E 00 0.99683E 00 0.99683E 00 0.99683E 00 0.99683E 00 0.99683E 00 0.99683E 00 0.99683E 00 0.99683E 00
  16   0.99210E 00 0.99210E 00 0.99210E 00 0.99210E 00 0.99210E 00 0.99210E 00 0.99210E 00 0.99210E 00 0.99210E 00 0.99210E 00
  15   0.98095E 00 0.98095E 00 0.98095E 00 0.98095E 00 0.98095E 00 0.98095E 00 0.98095E 00 0.98095E 00 0.98095E 00 0.98095E 00
  14   0.95525E 00 0.95525E 00 0.95525E 00 0.95525E 00 0.95525E 00 0.95525E 00 0.95525E 00 0.95525E 00 0.95525E 00 0.95525E 00
  13   0.89887E 00 0.89887E 00 0.89887E 00 0.89887E 00 0.89887E 00 0.89887E 00 0.89887E 00 0.89887E 00 0.89887E 00 0.89887E 00
  12   0.78758E 00 0.78758E 00 0.78758E 00 0.78758E 00 0.78758E 00 0.78758E 00 0.78758E 00 0.78758E 00 0.78758E 00 0.78758E 00
  11   0.60748E 00 0.60748E 00 0.60748E 00 0.60748E 00 0.60748E 00 0.60748E 00 0.60748E 00 0.60748E 00 0.60748E 00 0.60748E 00
  10   0.39252E 00 0.39252E 00 0.39252E 00 0.39252E 00 0.39252E 00 0.39252E 00 0.39252E 00 0.39252E 00 0.39252E 00 0.39252E 00
   9   0.21242E 00 0.21242E 00 0.21242E 00 0.21242E 00 0.21242E 00 0.21242E 00 0.21242E 00 0.21242E 00 0.21242E 00 0.21242E 00
   8   0.10113E 00 0.10113E 00 0.10113E 00 0.10113E 00 0.10113E 00 0.10113E 00 0.10113E 00 0.10113E 00 0.10113E 00 0.10113E 00
   7   0.44748E-01 0.44748E-01 0.44748E-01 0.44748E-01 0.44748E-01 0.44748E-01 0.44748E-01 0.44748E-01 0.44748E-01 0.44748E-01
   6   0.19050E-01 0.19050E-01 0.19050E-01 0.19050E-01 0.19050E-01 0.19050E-01 0.19050E-01 0.19050E-01 0.19050E-01 0.19050E-01
   5   0.79030E-02 0.79030E-02 0.79030E-02 0.79030E-02 0.79030E-02 0.79030E-02 0.79030E-02 0.79030E-02 0.79030E-02 0.79030E-02
   4   0.31715E-02 0.31715E-02 0.31715E-02 0.31715E-02 0.31715E-02 0.31715E-02 0.31715E-02 0.31715E-02 0.31715E-02 0.31715E-02
   3   0.11819E-02 0.11819E-02 0.11819E-02 0.11819E-02 0.11819E-02 0.11819E-02 0.11819E-02 0.11819E-02 0.11819E-02 0.11819E-02
   2   0.34851E-03 0.34851E-03 0.34851E-03 0.34851E-03 0.34851E-03 0.34851E-03 0.34851E-03 0.34851E-03 0.34851E-03 0.34851E-03
   1  -0.10857E-15-0.10857E-15-0.10857E-15-0.10857E-15-0.10857E-15-0.10857E-15-0.10857E-15-0.10857E-15-0.10857E-15-0.10857E-15

0LZ=       11        12        13        14        15        16        17        18        19        20
  Z=   0.105263E 010.115789E 010.126316E 010.136842E 010.147368E 010.157895E 010.168421E 010.178947E 010.189474E 010.200000E 01
```

```
20   0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01
19   0.99965E 00 0.99965E 00 0.99965E 00 0.99965E 00 0.99965E 00 0.99965E 00 0.99965E 00 0.99965E 00 0.99965E 00 0.99965E 00
18   0.99882E 00 0.99882E 00 0.99882E 00 0.99882E 00 0.99882E 00 0.99882E 00 0.99882E 00 0.99882E 00 0.99882E 00 0.99882E 00
17   0.99683E 00 0.99683E 00 0.99683E 00 0.99683E 00 0.99683E 00 0.99683E 00 0.99683E 00 0.99683E 00 0.99683E 00 0.99683E 00
16   0.99210E 00 0.99210E 00 0.99210E 00 0.99210E 00 0.99210E 00 0.99210E 00 0.99210E 00 0.99210E 00 0.99210E 00 0.99210E 00
15   0.98095E 00 0.98095E 00 0.98095E 00 0.98095E 00 0.98095E 00 0.98095E 00 0.98095E 00 0.98095E 00 0.98095E 00 0.98095E 00
14   0.95525E 00 0.95525E 00 0.95525E 00 0.95525E 00 0.95525E 00 0.95525E 00 0.95525E 00 0.95525E 00 0.95525E 00 0.95525E 00
13   0.89887E 00 0.89887E 00 0.89887E 00 0.89887E 00 0.89887E 00 0.89887E 00 0.89887E 00 0.89887E 00 0.89887E 00 0.89887E 00
12   0.78758E 00 0.78758E 00 0.78758E 00 0.78758E 00 0.78758E 00 0.78758E 00 0.78758E 00 0.78758E 00 0.78758E 00 0.78758E 00
11   0.60748E 00 0.60748E 00 0.60748E 00 0.60748E 00 0.60748E 00 0.60748E 00 0.60748E 00 0.60748E 00 0.60748E 00 0.60748E 00
10   0.39252E 00 0.39252E 00 0.39252E 00 0.39252E 00 0.39252E 00 0.39252E 00 0.39252E 00 0.39252E 00 0.39252E 00 0.39252E 00
 9   0.21242E 00 0.21242E 00 0.21242E 00 0.21242E 00 0.21242E 00 0.21242E 00 0.21242E 00 0.21242E 00 0.21242E 00 0.21242E 00
 8   0.10113E 00 0.10113E 00 0.10113E 00 0.10113E 00 0.10113E 00 0.10113E 00 0.10113E 00 0.10113E 00 0.10113E 00 0.10113E 00
 7   0.44748E-01 0.44748E-01 0.44748E-01 0.44748E-01 0.44748E-01 0.44748E-01 0.44748E-01 0.44748E-01 0.44748E-01 0.44748E-01
 6   0.19050E-01 0.19050E-01 0.19050E-01 0.19050E-01 0.19050E-01 0.19050E-01 0.19050E-01 0.19050E-01 0.19050E-01 0.19050E-01
 5   0.79030E-02 0.79030E-02 0.79030E-02 0.79030E-02 0.79030E-02 0.79030E-02 0.79030E-02 0.79030E-02 0.79030E-02 0.79030E-02
 4   0.31715E-02 0.31715E-02 0.31715E-02 0.31715E-02 0.31715E-02 0.31715E-02 0.31715E-02 0.31715E-02 0.31715E-02 0.31715E-02
 3   0.11819E-02 0.11819E-02 0.11819E-02 0.11819E-02 0.11819E-02 0.11819E-02 0.11819E-02 0.11819E-02 0.11819E-02 0.11819E-02
 2   0.34851E-03 0.34851E-03 0.34851E-03 0.34851E-03 0.34851E-03 0.34851E-03 0.34851E-03 0.34851E-03 0.34851E-03 0.34851E-03
 1  -0.10857E-15-0.10857E-15-0.10857E-15-0.10857E-15-0.10857E-15-0.10857E-15-0.10857E-15-0.10857E-15-0.10857E-15-0.10857E-15
OGEOMETRY DATA AT TSTEP NO.    0    GTIME =    0.00000000

O***** X3-COORD-FIX *****

OLZ=      1           2           3           4           5           6           7           8           9          10
  Z=  0.0000000.105263E 000.210526E 000.315789E 000.421053E 000.526316E 000.631579E 000.736842E 000.842105E 000.947368E 00

20   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00
19   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00
18   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00
17   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00
16   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00
15   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00
14   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00
13   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00
12   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00
11   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00
10   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00
 9   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00
 8   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00
 7   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00
 6   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00
 5   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00
 4   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00
 3   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00
 2   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00
 1   0.00000 0.10526E 00 0.21053E 00 0.31579E 00 0.42105E 00 0.52632E 00 0.63158E 00 0.73684E 00 0.84211E 00 0.94737E 00

OLZ=     11          12          13          14          15          16          17          18          19          20
  Z=  0.105263E 010.115789E 010.126316E 010.136842E 010.147368E 010.157895E 010.168421E 010.178947E 010.189474E 010.200000E 01

20   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
19   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
18   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
17   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
16   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
15   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
14   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
13   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
12   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
11   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
10   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
 9   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
 8   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
 7   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
 6   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
 5   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
 4   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
 3   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
 2   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
 1   0.10526E 01 0.11579E 01 0.12632E 01 0.13684E 01 0.14737E 01 0.15789E 01 0.16842E 01 0.17895E 01 0.18947E 01 0.20000E 01
&INFLW
CFLW= 0.1660D-02
DELTAL= 0.121490
PRDL= 1.0
CFUW= 0.1660D-02
DELTAU= 0.121490
PRDU= 1.0
TINF= 287.6230
```

```
&END
1
   1    0.000000      0.000000 0.103851E 01 0.962918E 00
   2 0.348505E-03 0.452883E 01 0.442439E 01 0.129883E 00 0.129897E 00 0.129883E 00 0.103786E 01 0.963521E 00 0.299720E-03
   3 0.118190E-02 0.153588E 02 0.105461E 02 0.309441E 00 0.309624E 00 0.309441E 00 0.103482E 01 0.966349E 00 0.343079E-02
   4 0.317153E-02 0.412141E 02 0.139703E 02 0.409731E 00 0.410157E 00 0.409731E 00 0.103204E 01 0.968950E 00 0.244238E-01
   5 0.790299E-02 0.102699E 03 0.164365E 02 0.481869E 00 0.482563E 00 0.481869E 00 0.102957E 01 0.971281E 00 0.147512E 00
   6 0.190504E-01 0.247561E 03 0.192304E 02 0.563477E 00 0.564589E 00 0.563477E 00 0.102628E 01 0.974390E 00 0.800417E 00
   7 0.447482E-01 0.581504E 03 0.241939E 02 0.708100E 00 0.710313E 00 0.708100E 00 0.101920E 01 0.981161E 00 0.369478E 01
   8 0.101126E 00 0.131414E 04 0.332628E 02 0.970824E 00 0.976570E 00 0.970824E 00 0.100221E 01 0.997791E 00 0.107855E 02
   9 0.212419E 00 0.276039E 04 0.356323E 02 0.103908E 01 0.104614E 01 0.100000E 01 0.100000E 01 0.100000E 01 0.113521E 02
  10 0.392518E 00 0.510077E 04 0.371247E 02 0.108197E 01 0.108995E 01 0.100000E 01 0.100000E 01 0.100000E 01 0.113521E 02
CFC,CF,UTAU =  0.182327E-02 0.166000E-02 0.293592E-01
YPLUSD,UPLUSD,PIXDK =  0.157876E 04 0.342750E 02 0.232718E 01
1
   1    0.000000      0.000000 0.103851E 01 0.962918E 00
   2 0.348505E-03 0.452883E 01 0.442439E 01 0.129883E 00 0.129897E 00 0.129883E 00 0.103786E 01 0.963521E 00 0.299720E-03
   3 0.118190E-02 0.153588E 02 0.105461E 02 0.309441E 00 0.309624E 00 0.309441E 00 0.103402E 01 0.966349E 00 0.343079E-02
   4 0.317153E-02 0.412141E 02 0.139703E 02 0.409731E 00 0.410157E 00 0.409731E 00 0.103204E 01 0.968350E 00 0.244238E-01
   5 0.790299E-02 0.102699E 03 0.164365E 02 0.481869E 00 0.482563E 00 0.481869E 00 0.102957E 01 0.971281E 00 0.147512E 00
   6 0.190504E-01 0.247561E 03 0.192304E 02 0.563477E 00 0.564589E 00 0.563477E 00 0.102623E 01 0.974390E 00 0.800417E 00
   7 0.447482E-01 0.581504E 03 0.241939E 02 0.708100E 00 0.710313E 00 0.708100E 00 0.101920E 01 0.981161E 00 0.369478E 01
   8 0.101126E 00 0.131414E 04 0.332628E 02 0.970824E 00 0.976570E 00 0.970824E 00 0.100221E 01 0.997791E 00 0.107855E 02
   9 0.212419E 00 0.276039E 04 0.356323E 02 0.103908E 01 0.104614E 01 0.100000E 01 0.100000E 01 0.100000E 01 0.113521E 02
  10 0.392518E 00 0.510077E 04 0.371247E 02 0.108197E 01 0.108995E 01 0.100000E 01 0.100000E 01 0.100000E 01 0.113521E 02
CFC,CF,UTAU =  0.182327E-02 0.166000E-02 0.293592E-01
YPLUSD,UPLUSD,PIXDK =  0.157876E 04 0.342750E 02 0.232718E 01
MZ,XMAX,AMCH,TDUM,PDUM,RDUM,WDUM
   1 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01
   2 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01
   3 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01
   4 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01
   5 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01
   6 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01
   7 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01
   8 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01
   9 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01
  10 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01
  11 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01
  12 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01
  13 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01
  14 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01
  15 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01
  16 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01
  17 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01
  18 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01
  19 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01
  20 0.100000E 01 0.438805E 00 0.100000E 01 0.100000E 01 0.100000E 01 0.100000E 01


   ********************************************************************************************
   ********************************************************************************************
1
&READ1
IREST= -1
IOTAPE= 10
INTAPE= 9
IOTAP1= 20
INTAP1= 19
&END
&READ9
NUMDX= 18
NUMDY= 0
NUMDZ= 18
XGMIN= 3*0.0
XGMAX= 1.0, 0.0, 2.0
GRID= -0.99950, 0.99950, 0.0, 0.0, 0.0, 0.0
XCENTR= 3*0.0
DAMPG= 3*0.0
IGEOM= 1
TWOD= T
IGTYPE= 1
LXSPLT= 10
LYSPLT= 1
REY= 473299.99367414
CLENG= 0.4410D-01
WREF= 149.176750
DENSR= 1.26921280
TREF= 287.6230
```

```
PREF= 104784.09706382
VISCR= 0.176415880D-04
CMACH= 0.43880492276718
LAMFLO= 0
AVISC= 15*0.50, 60*0.0
NT= 3
DT= 0.50D-02
DTMIN= 0.10D-02
DTMAX= 0.10D0
IDTADJ= 1
NTSTEP= 3
ITEST= 1
SSEPS= 0.99999993108213D-03
IPRINT= 10
LZPRNT= 61*1
IVARPR= 28*1, 4*0, 1, 0, 1, 5*0
IDUMP1= 1
IPLOT= 0
NFPLOT= 0
IGPRT= 1, 0, 1, 17*0
ICASE= 1
PRESS6= 0.9930
&END
&DATA1
NCLUST= 1
NEND= 0
BETA0= 0.10526315789474
ETAP= 2.0, 20.0, 59*0.0
ALPH= 2*1.0, 59*0.0
YFIRST= 0.0
YLAST= 2.0
CLPX= 1.0, 20.0, 59*0.0
CLPY= 0.0, 2.0, 59*0.0
RATIO= 1.0, 39*0.0
BET= 61*0.0
RHW= 1.0
&END
1
0 START -- TOTAL MASS = 0.1985675364E 01   TOTAL ENERGY = 0.1561919368E 01
  CURRENT -- TOTAL MASS = 0.1985675364E 01   TOTAL ENERGY = 0.1561919368E 01
  PERCENT DIFFERENCE -- IN MASS = 0.00000          IN ENERGY = 0.00000


         MASS FLUX AT IDT =     0
         LZ     MASS FLUX
          1   0.93722E 00
          2   0.93687E 00
          3   0.93653E 00
          4   0.93618E 00
          5   0.93584E 00
          6   0.93549E 00
          7   0.93515E 00
          8   0.93480E 00
          9   0.93446E 00
         10   0.93411E 00
         11   0.93377E 00
         12   0.93342E 00
         13   0.93308E 00
         14   0.93273E 00
         15   0.93239E 00
         16   0.93204E 00
         17   0.93169E 00
         18   0.93135E 00
         19   0.93100E 00
         20   0.93066E 00
1***** STARTING FLOW FIELD *****
0RESULTS AT TSTEP NO.    0    TIME =    0.000000

0***** U-VL        *****

0LZ=     1          2          3          4          5          6          7          8          9          10
  Z=     0.0000000.105263E 000.210526E 000.315789E 000.421053E 000.526316E 000.631579E 000.736842E 000.842105E 000.947368E 00

   20   0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000
   19   0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000
   18   0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000
   17   0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000
   16   0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000
```

```
  15     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
  14     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
  13     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
  12     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
  11     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
  10     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
   9     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
   8     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
   7     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
   6     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
   5     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
   4     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
   3     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
   2     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
   1     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000

OLZ=     11           12           13           14           15           16           17           18           19           20
  Z= 0.105263E 010.115789E 010.126316E 010.136842E 010.147368E 010.157895E 010.168421E 010.178947E 010.189474E 010.200000E 01

  20     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
  19     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
  18     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
  17     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
  16     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
  15     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00500
  14     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
  13     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.05000
  12     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
  11     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00300
  10     0.00000      0.00000      0.00000      0.00000      0.00000      0.00003      0.00000      0.00000      0.00000      0.00000
   9     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
   8     0.00000      0.00000      0.00000      0.00000      0.00000      0.00030      0.00000      0.00000      0.00000      0.00000
   7     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
   6     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00300
   5     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
   4     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
   3     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
   2     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
   1     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
ORESULTS AT TSTEP NO.    0    TIME =    0.000000

O***** W-VL        *****

OLZ=     1            2            3            4            5            6            7            8            9            10
  Z= 0.0000000.105263E 000.210526E 000.315789E 000.421053E 000.526316E 000.631579E 000.736842E 000.842105E 000.947368E 00
  20     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
  19  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00
  18  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00
  17  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00
  16  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00
  15  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00
  14  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00
  13  0.97082E 00  0.97082E 00  0.97082E 00  0.97082E 00  0.97082E 00  0.97082E 00  0.97082E 00  0.97082E 00  0.97082E 00  0.97082E 00
  12  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01
  11  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01
  10  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01
   9  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01
   8  0.97082E 00  0.97082E 00  0.97082E 00  0.97082E 00  0.97082E 00  0.97082E 00  0.97032E 00  0.97082E 00  0.97082E 00  0.97082E 00
   7  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00
   6  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00
   5  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00
   4  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00
   3  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00
   2  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00
   1     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000

OLZ=     11           12           13           14           15           16           17           18           19           20
  Z= 0.105263E 010.115789E 010.126316E 010.136842E 010.147368E 010.157895E 010.168421E 010.178947E 010.189474E 010.200000E 01

  20     0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
  19  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00  0.12988E 00
  18  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00  0.30944E 00
  17  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00  0.40973E 00
  16  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00  0.48187E 00
  15  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00  0.56348E 00
  14  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00  0.70810E 00
  13  0.97082E 00  0.97082E 00  0.97082E 00  0.97082E 00  0.97082E 00  0.97082E 00  0.97082E 00  0.97082E 00  0.97082E 00  0.97082E 00
  12  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01
  11  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01  0.10000E 01
```

```
10    0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01
 9    0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01
 8    0.97082E 00 0.97082E 00 0.97082E 00 0.97082E 00 0.97082E 00 0.97082E 00 0.97082E 00 0.97032E 00 0.97082E 00 0.97082E 00
 7    0.70810E 00 0.70810E 00 0.70810E 00 0.70810E 00 0.70810E 00 0.70810E 00 0.70810E 00 0.70810E 00 0.70810E 00 0.70810E 00
 6    0.56348E 00 0.56348E 00 0.56348E 00 0.56348E 00 0.56348E 00 0.56348E 00 0.56348E 00 0.56348E 00 0.56348E 00 0.56343E 00
 5    0.48187E 00 0.48187E 00 0.48187E 00 0.48187E 00 0.48187E 00 0.48187E 00 0.48187E 00 0.48187E 00 0.48187E 00 0.48187E 00
 4    0.40973E 00 0.40973E 00 0.40973E 00 0.40973E 00 0.40973E 00 0.40973E 00 0.40973E 00 0.40973E 00 0.40973E 00 0.40973E 00
 3    0.30944E 00 0.30944E 00 0.30944E 00 0.30944E 00 0.30944E 00 0.30944E 00 0.30944E 00 0.30944E 00 0.30944E 00 0.30944E 00
 2    0.12988E 00 0.12938E 00 0.12988E 00 0.12988E 00 0.12988E 00 0.12938E 00 0.12988E 00 0.12988E 00 0.12938E 00 0.12988E 00
 1    0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00003
ORESULTS AT TSTEP NO.    0    TIME =    0.000000

0***** DENS        *****

0LZ=      1          2          3          4          5          6          7          8          9          10
  Z=     0.0000000.105263E 000.210526E 000.315789E 000.421053E 000.526316E 000.631579E 000.736842E 000.842105E 000.947368E 00

 20   0.96293E 00 0.96257E 00 0.96222E 00 0.96186E 00 0.96151E 00 0.96115E 00 0.96080E 00 0.96044E 00 0.96009E 00 0.95973E 00
 19   0.96353E 00 0.96317E 00 0.96282E 00 0.96246E 00 0.96211E 00 0.96175E 00 0.96140E 00 0.96104E 00 0.96069E 00 0.96033E 00
 18   0.96636E 00 0.96600E 00 0.96565E 00 0.96529E 00 0.96493E 00 0.96458E 00 0.96422E 00 0.96386E 00 0.96351E 00 0.96315E 00
 17   0.96896E 00 0.96860E 00 0.96824E 00 0.96789E 00 0.96753E 00 0.96717E 00 0.96682E 00 0.96646E 00 0.96610E 00 0.96574E 00
 16   0.97129E 00 0.97093E 00 0.97057E 00 0.97021E 00 0.96986E 00 0.96950E 00 0.96914E 00 0.96878E 00 0.96843E 00 0.96807E 00
 15   0.97440E 00 0.97404E 00 0.97368E 00 0.97332E 00 0.97296E 00 0.97260E 00 0.97224E 00 0.97188E 00 0.97152E 00 0.97117E 00
 14   0.98117E 00 0.98080E 00 0.98044E 00 0.93008E 00 0.97972E 00 0.97936E 00 0.97900E 00 0.97863E 00 0.97827E 00 0.97791E 00
 13   0.99779E 00 0.99742E 00 0.99706E 00 0.99669E 00 0.99632E 00 0.99595E 00 0.99559E 00 0.99522E 00 0.99485E 00 0.99448E 00
 12   0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
 11   0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99353E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
 10   0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
  9   0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99316E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
  8   0.99779E 00 0.99742E 00 0.99706E 00 0.99669E 00 0.99632E 00 0.99595E 00 0.99559E 00 0.99522E 00 0.99485E 00 0.99448E 00
  7   0.98117E 00 0.98080E 00 0.98044E 00 0.98008E 00 0.97972E 00 0.97936E 00 0.97900E 00 0.97863E 00 0.97827E 00 0.97791E 00
  6   0.97440E 00 0.97404E 00 0.97368E 00 0.97332E 00 0.97296E 00 0.97260E 00 0.97224E 00 0.97188E 00 0.97152E 00 0.97117E 00
  5   0.97129E 00 0.97093E 00 0.97057E 00 0.97021E 00 0.96986E 00 0.96950E 00 0.96914E 00 0.96378E 00 0.96843E 00 0.96807E 00
  4   0.96896E 00 0.96860E 00 0.96824E 00 0.96739E 00 0.96753E 00 0.96717E 00 0.96632E 00 0.96646E 00 0.96610E 00 0.96574E 00
  3   0.96636E 00 0.96600E 00 0.96565E 00 0.96529E 00 0.96493E 00 0.96458E 00 0.96422E 00 0.96386E 00 0.96351E 00 0.96315E 00
  2   0.96353E 00 0.96317E 00 0.96282E 00 0.96246E 00 0.96211E 00 0.96175E 00 0.96140E 00 0.96104E 00 0.96069E 00 0.96033E 00
  1   0.96293E 00 0.96257E 00 0.96222E 00 0.96186E 00 0.96151E 00 0.96115E 00 0.96080E 00 0.96044E 00 0.96009E 00 0.95973E 00


0LZ=     11         12         13         14         15         16         17         18         19         20
  Z=   0.105263E 010.115789E 010.126316E 010.136842E 010.147368E 010.157895E 010.168421E 010.178947E 010.189474E 010.200000E 01

 20   0.95938E 00 0.95902E 00 0.95867E 00 0.95831E 00 0.95796E 00 0.95761E 00 0.95725E 00 0.95690E 00 0.95654E 00 0.95619E 00
 19   0.95998E 00 0.95962E 00 0.95927E 00 0.95891E 00 0.95856E 00 0.95820E 00 0.95785E 00 0.95749E 00 0.95714E 00 0.95678E 00
 18   0.96280E 00 0.96244E 00 0.96208E 00 0.96173E 00 0.96137E 00 0.96102E 00 0.96066E 00 0.96030E 00 0.95995E 00 0.95959E 00
 17   0.96539E 00 0.96503E 00 0.96467E 00 0.96432E 00 0.96396E 00 0.96360E 00 0.96325E 00 0.96289E 00 0.96253E 00 0.96217E 00
 16   0.96771E 00 0.96735E 00 0.96699E 00 0.96664E 00 0.96628E 00 0.96592E 00 0.96556E 00 0.96520E 00 0.96485E 00 0.96449E 00
 15   0.97081E 00 0.97045E 00 0.97009E 00 0.96973E 00 0.96937E 00 0.96901E 00 0.96865E 00 0.96829E 00 0.96793E 00 0.96758E 00
 14   0.97755E 00 0.97719E 00 0.97683E 00 0.97647E 00 0.97610E 00 0.97574E 00 0.97538E 00 0.97502E 00 0.97466E 00 0.97430E 00
 13   0.99412E 00 0.99375E 00 0.99338E 00 0.99301E 00 0.99264E 00 0.99228E 00 0.99191E 00 0.99154E 00 0.99117E 00 0.99081E 00
 12   0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
 11   0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
 10   0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
  9   0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
  8   0.99412E 00 0.99375E 00 0.99338E 00 0.99301E 00 0.99264E 00 0.99228E 00 0.99191E 00 0.99154E 00 0.99117E 00 0.99081E 00
  7   0.97755E 00 0.97719E 00 0.97683E 00 0.97647E 00 0.97610E 00 0.97574E 00 0.97533E 00 0.97502E 00 0.97466E 00 0.97430E 00
  6   0.97081E 00 0.97045E 00 0.97009E 00 0.96973E 00 0.96937E 00 0.96901E 00 0.96865E 00 0.96829E 00 0.96793E 00 0.96753E 00
  5   0.96771E 00 0.96735E 00 0.96699E 00 0.96664E 00 0.96628E 00 0.96592E 00 0.96556E 00 0.96520E 00 0.96455E 00 0.96449E 00
  4   0.96539E 00 0.96503E 00 0.96467E 00 0.96432E 00 0.96396E 00 0.96360E 00 0.96325E 00 0.96289E 00 0.96253E 00 0.96217E 00
  3   0.96280E 00 0.96244E 00 0.96208E 00 0.96173E 00 0.96137E 00 0.96102E 00 0.96066E 00 0.96030E 00 0.95995E 00 0.95959E 00
  2   0.95998E 00 0.95962E 00 0.95927E 00 0.95891E 00 0.95856E 00 0.95820E 00 0.95785E 00 0.95749E 00 0.95714E 00 0.95678E 00
  1   0.95938E 00 0.95902E 00 0.95867E 00 0.95831E 00 0.95796E 00 0.95761E 00 0.95725E 00 0.95690E 00 0.95654E 00 0.95619E 00
ORESULTS AT TSTEP NO.    0    TIME =    0.000000

0***** PRES        *****

0LZ=      1          2          3          4          5          6          7          8          9          10
  Z=     0.0000000.105263E 000.210526E 000.315789E 000.421053E 000.526316E 000.631579E 000.736842E 000.842105E 000.947368E 00

 20   0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
 19   0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
 18   0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
 17   0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
 16   0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
 15   0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
 14   0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
 13   0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
 12   0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
 11   0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
 10   0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
  9   0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
```

```
   8  0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99663E 00
   7  0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
   6  0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
   5  0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
   4  0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
   3  0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
   2  0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
   1  0.10000E 01 0.99963E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00

OLZ=     11        12        13        14        15        16        17        18        19        20
  Z= 0.105263E 010.115789E 010.126316E 010.136842E 010.147368E 010.157895E 010.168421E 010.178947E 010.189474E 010.200000E 01

  20  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
  19  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
  18  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
  17  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
  16  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
  15  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
  14  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
  13  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
  12  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
  11  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
  10  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
   9  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
   8  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
   7  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
   6  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
   5  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
   4  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
   3  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
   2  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
   1  0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
ORESULTS AT TSTEP NO.    0    TIME =    0.000000

O***** TEMP        *****

OLZ=      1         2         3         4         5         6         7         8         9        10
  Z=   0.0000000.105263E 000.210526E 000.315789E 000.421053E 000.526316E 000.631579E 000.736842E 000.842105E 000.947368E 00

  20  0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01
  19  0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01
  18  0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01
  17  0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01
  16  0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01
  15  0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01
  14  0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01
  13  0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E.01
  12  0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01
  11  0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01
  10  0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01
   9  0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01
   8  0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01
   7  0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01
   6  0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01
   5  0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01
   4  0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01
   3  0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01
   2  0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01
   1  0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01

OLZ=     11        12        13        14        15        16        17        18        19        20
  Z= 0.105263E 010.115789E 010.126316E 010.136842E 010.147368E 010.157895E 010.168421E 010.178947E 010.189474E 010.200000E 01

  20  0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01
  19  0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01 0.10379E 01
  18  0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01 0.10348E 01
  17  0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01
  16  0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01
  15  0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01
  14  0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01
  13  0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01
  12  0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01
  11  0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01
  10  0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01
   9  0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01 0.10000E 01
   8  0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01
   7  0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01
   6  0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01 0.10263E 01
   5  0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01 0.10296E 01
   4  0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01
```

```
                1          2          3          4          5          6          7          8          9          10
            0.0000000.105263E 000.210526E 000.315789E 000.421053E 000.526316E 000.631579E 000.736842E 000.842105E 000.947368E 00
20  0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01
19  0.10824E 01 0.10824E 01 0.10824E 01 0.10823E 01 0.10823E 01 0.10823E 01 0.10822E 01 0.10822E 01 0.10822E 01 0.10822E 01
18  0.16983E 01 0.16978E 01 0.16974E 01 0.16969E 01 0.16965E 01 0.16960E 01 0.16956E 01 0.16951E 01 0.16947E 01 0.16942E 01
17  0.31125E 01 0.31111E 01 0.31097E 01 0.31084E 01 0.31070E 01 0.31056E 01 0.31042E 01 0.31028E 01 0.31014E 01 0.31001E 01
16  0.10251E 02 0.10245E 02 0.10239E 02 0.10234E 02 0.10228E 02 0.10222E 02 0.10216E 02 0.10210E 02 0.10204E 02 0.10198E 02
15  0.69498E 02 0.69460E 02 0.69422E 02 0.69383E 02 0.69345E 02 0.69307E 02 0.69268E 02 0.69230E 02 0.69192E 02 0.69154E 02
14  0.31579E 03 0.31565E 03 0.31551E 03 0.31536E 03 0.31522E 03 0.31508E 03 0.31494E 03 0.31480E 03 0.31466E 03 0.31452E 03
13  0.18180E 03 0.18173E 03 0.18165E 03 0.18158E 03 0.18151E 03 0.18143E 03 0.18136E 03 0.18128E 03 0.18121E 03 0.18114E 03
12  0.12350E 02 0.12346E 02 0.12342E 02 0.12337E 02 0.12333E 02 0.12329E 02 0.12325E 02 0.12321E 02 0.12317E 02 0.12312E 02
11  0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01
10  0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01
 9  0.12350E 02 0.12346E 02 0.12342E 02 0.12337E 02 0.12333E 02 0.12329E 02 0.12325E 02 0.12321E 02 0.12317E 02 0.12312E 02
 8  0.18180E 03 0.18173E 03 0.18165E 03 0.18158E 03 0.18151E 03 0.18143E 03 0.18136E 03 0.18128E 03 0.18121E 03 0.18114E 03
 7  0.31579E 03 0.31565E 03 0.31551E 03 0.31536E 03 0.31522E 03 0.31508E 03 0.31494E 03 0.31480E 03 0.31466E 03 0.31452E 03
 6  0.69498E 02 0.69460E 02 0.69422E 02 0.69383E 02 0.69345E 02 0.69307E 02 0.69268E 02 0.69230E 02 0.69192E 02 0.69154E 02
 5  0.10251E 02 0.10245E 02 0.10239E 02 0.10234E 02 0.10228E 02 0.10222E 02 0.10216E 02 0.10210E 02 0.10204E 02 0.10198E 02
 4  0.31125E 01 0.31111E 01 0.31097E 01 0.31084E 01 0.31070E 01 0.31056E 01 0.31042E 01 0.31028E 01 0.31014E 01 0.31001E 01
 3  0.16983E 01 0.16978E 01 0.16974E 01 0.16969E 01 0.16965E 01 0.16960E 01 0.16956E 01 0.16951E 01 0.16947E 01 0.16942E 01
 2  0.10824E 01 0.10824E 01 0.10824E 01 0.10823E 01 0.10823E 01 0.10823E 01 0.10822E 01 0.10822E 01 0.10822E 01 0.10822E 01
 1  0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01
```

OLZ=

Z=
```
               11         12         13         14         15         16         17         18         19         20
          0.105263E 010.115789E 010.126316E 010.136842E 010.147368E 010.157895E 010.168421E 010.178947E 010.189474E 010.200000E 01
20  0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01
19  0.10821E 01 0.10821E 01 0.10821E 01 0.10821E 01 0.10820E 01 0.10820E 01 0.10820E 01 0.10820E 01 0.10819E 01 0.10819E 01
18  0.16938E 01 0.16933E 01 0.16929E 01 0.16924E 01 0.16920E 01 0.16915E 01 0.16911E 01 0.16906E 01 0.16902E 01 0.16897E 01
17  0.30987E 01 0.30973E 01 0.30959E 01 0.30945E 01 0.30932E 01 0.30918E 01 0.30904E 01 0.30890E 01 0.30876E 01 0.30863E 01
16  0.10193E 02 0.10187E 02 0.10181E 02 0.10175E 02 0.10169E 02 0.10163E 02 0.10158E 02 0.10152E 02 0.10146E 02 0.10140E 02
15  0.69115E 02 0.69077E 02 0.69039E 02 0.69001E 02 0.68962E 02 0.68924E 02 0.68886E 02 0.68848E 02 0.68809E 02 0.68771E 02
14  0.31438E 03 0.31424E 03 0.31409E 03 0.31395E 03 0.31381E 03 0.31367E 03 0.31353E 03 0.31339E 03 0.31325E 03 0.31311E 03
13  0.18106E 03 0.18099E 03 0.18091E 03 0.18084E 03 0.18077E 03 0.18069E 03 0.18062E 03 0.18054E 03 0.18047E 03 0.18040E 03
12  0.12308E 02 0.12304E 02 0.12300E 02 0.12296E 02 0.12292E 02 0.12287E 02 0.12283E 02 0.12279E 02 0.12275E 02 0.12271E 02
11  0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01
10  0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01 0.10130E 01
 9  0.12308E 02 0.12304E 02 0.12300E 02 0.12296E 02 0.12292E 02 0.12287E 02 0.12283E 02 0.12279E 02 0.12275E 02 0.12271E 02
 8  0.18106E 03 0.18099E 03 0.18091E 03 0.18084E 03 0.18077E 03 0.18069E 03 0.18062E 03 0.18054E 03 0.18047E 03 0.18040E 03
 7  0.31438E 03 0.31424E 03 0.31409E 03 0.31395E 03 0.31381E 03 0.31367E 03 0.31353E 03 0.31339E 03 0.31325E 03 0.31311E 03
 6  0.69115E 02 0.69077E 02 0.69035E 02 0.69001E 02 0.68962E 02 0.68924E 02 0.68886E 02 0.68848E 02 0.68809E 02 0.68771E 02
 5  0.10193E 02 0.10187E 02 0.10181E 02 0.10175E 02 0.10169E 02 0.10163E 02 0.10158E 02 0.10152E 02 0.10146E 02 0.10140E 02
 4  0.30987E 01 0.30973E 01 0.30959E 01 0.30945E 01 0.30932E 01 0.30918E 01 0.30904E 01 0.30890E 01 0.30876E 01 0.30863E 01
 3  0.16938E 01 0.16933E 01 0.16929E 01 0.16924E 01 0.16920E 01 0.16915E 01 0.16911E 01 0.16906E 01 0.16902E 01 0.16897E 01
 2  0.10821E 01 0.10821E 01 0.10821E 01 0.10820E 01 0.10820E 01 0.10820E 01 0.10819E 01 0.10819E 01 0.10819E 01 0.10819E 01
 1  0.10431E 01 0.10431E 01 0.10431E 01 0.10820E 01 0.10820E 01 0.10820E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01
```

0RESULTS AT TSTEP NO.   0   TIME =   0.000000

0***** MIXL   *****

OLZ=

Z=
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                1          2          3          4          5          6          7          8          9          10
          0.0000000.105263E 000.210526E 000.315789E 000.421053E 000.526316E 000.631579E 000.736842E 000.842105E 000.947368E 00
20   0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
19  0.18270E-04 0.18267E-04 0.18264E-04 0.18261E-04 0.18258E-04 0.18254E-04 0.18251E-04 0.18248E-04 0.18245E-04 0.18242E-04
18  0.12048E-03 0.12046E-03 0.12044E-03 0.12042E-03 0.12040E-03 0.12038E-03 0.12036E-03 0.12034E-03 0.12032E-03 0.12030E-03
17  0.41990E-03 0.41984E-03 0.41977E-03 0.41971E-03 0.41965E-03 0.41959E-03 0.41952E-03 0.41946E-03 0.41940E-03 0.41933E-03
16  0.14388E-02 0.14386E-02 0.14385E-02 0.14383E-02 0.14381E-02 0.14379E-02 0.14377E-02 0.14375E-02 0.14373E-02 0.14371E-02
15  0.49171E-02 0.49167E-02 0.49162E-02 0.49157E-02 0.49153E-02 0.49148E-02 0.49143E-02 0.49138E-02 0.49134E-02 0.49129E-02
14  0.11686E-01 0.11686E-01 0.11685E-01 0.11685E-01 0.11684E-01 0.11684E-01 0.11683E-01 0.11683E-01 0.11683E-01 0.11682E-01
13  0.14829E-01 0.14829E-01 0.14828E-01 0.14828E-01 0.14828E-01 0.14827E-01 0.14827E-01 0.14827E-01 0.14826E-01 0.14826E-01
12  0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01
11  0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01
10  0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01
 9  0.14829E-01 0.14829E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01
 8  0.11686E-01 0.11686E-01 0.14828E-01 0.14828E-01 0.14828E-01 0.14827E-01 0.14827E-01 0.14827E-01 0.15467E-01 0.15467E-01
 7  0.49171E-02 0.49167E-02 0.11685E-01 0.11685E-01 0.11684E-01 0.11684E-01 0.11683E-01 0.11683E-01 0.14826E-01 0.14826E-01
 6  0.14388E-02 0.14386E-02 0.49162E-02 0.49157E-02 0.49153E-02 0.49148E-02 0.49143E-02 0.49138E-02 0.11683E-01 0.11682E-01
 5  0.41990E-03 0.41984E-03 0.14385E-02 0.14383E-02 0.14381E-02 0.14379E-02 0.14377E-02 0.14375E-02 0.49134E-02 0.49129E-02
 4  0.12048E-03 0.12046E-03 0.41977E-03 0.41971E-03 0.41965E-03 0.41959E-03 0.41952E-03 0.41946E-03 0.14373E-02 0.14371E-02
 3  0.18270E-04 0.18267E-04 0.12044E-03 0.12042E-03 0.12040E-03 0.12038E-03 0.12036E-03 0.12034E-03 0.41940E-03 0.41933E-03
 2              0.18264E-04 0.18261E-04 0.18258E-04 0.18254E-04 0.18251E-04 0.12032E-03 0.12030E-03
                                        0.18248E-04 0.18245E-04 0.18242E-04
```

```
    1      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000

0LZ=      11          12          13          14          15          16          17          18          19          20
  Z=  0.105263 010.115789 010.126316 010.136842 010.147368 010.157895 010.168421 010.178947 010.189474 010.200000 01

   20      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
   19  0.18239E-04 0.18236E-04 0.18233E-04 0.18229E-04 0.18226E-04 0.18223E-04 0.18220E-04 0.18217E-04 0.18214E-04 0.18210E-04
   18  0.12028E-03 0.12027E-03 0.12025E-03 0.12023E-03 0.12021E-03 0.12019E-03 0.12017E-03 0.12015E-03 0.12013E-03 0.12011E-03
   17  0.41927E-03 0.41921E-03 0.41915E-03 0.41908E-03 0.41902E-03 0.41896E-03 0.41889E-03 0.41883E-03 0.41877E-03 0.41870E-03
   16  0.14369E-02 0.14367E-02 0.14365E-02 0.14363E-02 0.14361E-02 0.14360E-02 0.14358E-02 0.14356E-02 0.14354E-02 0.14352E-02
   15  0.49124E-02 0.49120E-02 0.49115E-02 0.49110E-02 0.49105E-02 0.49101E-02 0.49096E-02 0.49091E-02 0.49086E-02 0.49082E-02
   14  0.11682E-01 0.11681E-01 0.11681E-01 0.11680E-01 0.11680E-01 0.11679E-01 0.11679E-01 0.11678E-01 0.11678E-01 0.11677E-01
   13  0.14826E-01 0.14825E-01 0.14825E-01 0.14825E-01 0.14825E-01 0.14824E-01 0.14824E-01 0.14824E-01 0.14823E-01 0.14823E-01
   12  0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01
   11  0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01
   10  0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01
    9  0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01 0.15467E-01
    8  0.14826E-01 0.14825E-01 0.14825E-01 0.14825E-01 0.14825E-01 0.14824E-01 0.14824E-01 0.14824E-01 0.14823E-01 0.14823E-01
    7  0.11682E-01 0.11681E-01 0.11681E-01 0.11680E-01 0.11680E-01 0.11679E-01 0.11679E-01 0.11678E-01 0.11678E-01 0.11677E-01
    6  0.49124E-02 0.49120E-02 0.49115E-02 0.49110E-02 0.49105E-02 0.49101E-02 0.49096E-02 0.49091E-02 0.49086E-02 0.49082E-02
    5  0.14369E-02 0.14367E-02 0.14365E-02 0.14363E-02 0.14361E-02 0.14360E-02 0.14358E-02 0.14356E-02 0.14354E-02 0.14352E-02
    4  0.41927E-03 0.41921E-03 0.41915E-03 0.41908E-03 0.41902E-03 0.41896E-03 0.41889E-03 0.41883E-03 0.41877E-03 0.41870E-03
    3  0.12028E-03 0.12027E-03 0.12025E-03 0.12023E-03 0.12021E-03 0.12019E-03 0.12017E-03 0.12015E-03 0.12013E-03 0.12011E-03
    2  0.18239E-04 0.18236E-04 0.18233E-04 0.18229E-04 0.18226E-04 0.18223E-04 0.18220E-04 0.18217E-04 0.18214E-04 0.18210E-04
    1      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
0RESULTS AT TSTEP NO.    0    TIME =    0.000000

0***** MACH        *****

0LZ=       1           2           3           4           5           6           7           8           9          10
  Z=   0.0000000.105263 000.210526 000.315789 000.421053 000.526316 000.631579 000.736842 000.842105 000.947368 00

   20      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
   19  0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01
   18  0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00
   17  0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00
   16  0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00
   15  0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00
   14  0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00
   13  0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00
   12  0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00
   11  0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00
   10  0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00
    9  0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43830E 00
    8  0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00
    7  0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00
    6  0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00
    5  0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00
    4  0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00
    3  0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00
    2  0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01
    1      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000

0LZ=      11          12          13          14          15          16          17          18          19          20
  Z=  0.105263 010.115789 010.126316 010.136842 010.147368 010.157895 010.168421 010.178947 010.189474 010.200000 01

   20      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
   19  0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01
   18  0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00
   17  0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00
   16  0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00
   15  0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00
   14  0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00
   13  0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00
   12  0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43830E 00
   11  0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00
   10  0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00
    9  0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43880E 00 0.43830E 00 0.43880E 00
    8  0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00 0.42553E 00
    7  0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00 0.30778E 00
    6  0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00 0.24407E 00
    5  0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00 0.20839E 00
    4  0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00 0.17698E 00
    3  0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00 0.13348E 00
    2  0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01 0.55944E-01
    1      0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
0 START -- TOTAL MASS = 0.1985675364E 01   TOTAL ENERGY = 0.1561919368E 01
  CURRENT -- TOTAL MASS = 0.1985706868E 01   TOTAL ENERGY = 0.1561953262E 01
  PERCENT DIFFERENCE -- IN MASS = 0.00159           IN ENERGY = 0.00217
```

```
0** TIME STEP NO.   1 CPTIME=  0.00 MIN. TPHYS= 0.50000E-02 DT= 0.50000E-02 VISC STAB= 0.122E-06 IDTADJ=  1
 ** SSTEST= 0.7961E-02 AT LX= 19 LY=  1 LZ= 20 RATIO=   7.961   MAX. CHANGE -- (IEQ)=
 ** ( 1)=-0.1641E-04   ( 3)=-0.7961E-02   ( 4)= 0.4877E-03  (
0** REAVG= 0.112E 01 RESMAX= 0.231E 01 LX= 11 LY=  1 LZ= 19
 IEQ= 1 RESAVG= 0.143E-03 RESEQ=-0.409E-03 LX=  7LY=  1 LZ=  3 IEQ= 3 RESAVG= 0.112E 01 RESEQ= 0.231E 01 LX= 11 LY=  1 LZ= 19
 IEQ= 4 RESAVG= 0.209E 00 RESEQ= 0.490E 00 LX= 11LY=  1 LZ= 19 IEQ=
 CONV - AMP(L,M,H),RMS CONV . CONV+DIFF, AMP(L,M,H),RMS DIFF
 MAX  -0.10000E 26  -0.10000E 26  -0.10000E 26  -0.10000E 26  -0.10000E 26  -0.10000E 26  -0.10000E 26  -0.10000E 26
 MIN   0.10000E 26   0.10000E 26   0.10000E 26   0.10000E 26   0.10000E 26   0.10000E 26   0.10000E 26   0.10000E 26
 DTISAV, JCBN= 0.20000E 03 0.14858E-03
              AN          VAR(N)       DVAR(N+1)   A/DT*DVAR    L1*DVAR      L2*DVAR      L3*DVAR       DVAR(*)     A/DT*DVAR*  L1*(DV-DV*

 EQ 1 VAR 1  0.96565E 00    0.00000 0.16050E-04 0.30996E-02-0.61176E-04    0.00000 0.89177E-09
 EQ 1 VAR 3     0.00000 0.30944E 00-0.12851E-02    0.00000 0.98861E-01    0.00000    0.00000
 EQ 1 VAR 4     0.00000 0.96565E 00-0.17707E-04    0.00000-0.91884E-01    0.00000    0.00000
 EQ= 1 A,L1,L2,L3,RES,SPLIT= 0.30996E-02 0.69157E-02    0.00000 0.89177E-09-0.89677E-06 0.38152E-02

 EQ 3 VAR 1     0.00000    0.00000 0.16050E-04    0.00000-0.21880E-02    0.00000    0.00000
 EQ 3 VAR 3  0.96565E 00 0.30944E 00-0.12851E-02-0.24818E 00-0.12999E-01    0.00000 0.83808E-04
 EQ 3 VAR 4  0.30944E 00 0.96565E 00-0.17707E-04-0.10958E-02    0.00000    0.00000 0.56482E-03
 EQ= 3 A,L1,L2,L3,RES,SPLIT=-0.24928E 00-0.15187E-01    0.00000 0.64863E-03-0.23471E 00 0.28081E-04

 EQ 4 VAR 1     0.00000    0.00000 0.16050E-04    0.00000-0.47840E-02    0.00000    0.00000
 EQ 4 VAR 3     0.00000 0.30944E 00-0.12851E-02    0.00000    0.00000    0.00000 0.10980E-03
 EQ 4 VAR 4  0.10000E 01 0.96565E 00-0.17707E-04-0.35414E-02    0.00000    0.00000 0.86212E-04
 EQ= 4 A,L1,L2,L3,RES,SPLIT=-0.35414E-02-0.47840E-02    0.00000 0.19601E-03 0.10466E-02-0.57593E-08

 LZ       Z             U-VEL         V-VEL      W-VEL       DENSITY     ENTHALPY     PBOT        PTOP         DP
  1  0.00000000    0.73010E-08    0.00000 0.99997E 00 0.10000E 01 0.10385E 01 0.10005E 01 0.10005E 01 0.10000E 01
  2 0.10526316E 00    0.73006E-08    0.00000 0.10001E 01 0.99965E 00 0.10385E 01 0.99988E 00 0.99988E 00 0.99964E 00
  3 0.21052632E 00    0.73002E-08    0.00000 0.10001E 01 0.99928E 00 0.10385E 01 0.99928E 00 0.99928E 00 0.99928E 00
  4 0.31578947E 00    0.72998E-08    0.00000 0.10001E 01 0.99891E 00 0.10385E 01 0.99891E 00 0.99891E 00 0.99891E 00
  5 0.42105263E 00    0.72994E-08    0.00000 0.10001E 01 0.99854E 00 0.10385E 01 0.99854E 00 0.99854E 00 0.99854E 00
  6 0.52631579E 00    0.72990E-08    0.00000 0.10001E 01 0.99818E 00 0.10385E 01 0.99817E 00 0.99817E 00 0.99817E 00
  7 0.63157895E 00    0.72986E-08    0.00000 0.10001E 01 0.99781E 00 0.10385E 01 0.99780E 00 0.99780E 00 0.99780E 00
  8 0.73684211E 00    0.72982E-08    0.00000 0.10001E 01 0.99744E 00 0.10385E 01 0.99743E 00 0.99743E 00 0.99743E 00
  9 0.84210526E 00    0.72978E-08    0.00000 0.10001E 01 0.99707E 00 0.10385E 01 0.99706E 00 0.99706E 00 0.99707E 00
 10 0.94736842E 00    0.72974E-08    0.00000 0.10001E 01 0.99670E 00 0.10385E 01 0.99669E 00 0.99669E 00 0.99670E 00
 11 0.10526316E 01    0.72970E-08    0.00000 0.10001E 01 0.99633E 00 0.10385E 01 0.99633E 00 0.99633E 00 0.99633E 00
 12 0.11578947E 01    0.72965E-08    0.00000 0.10001E 01 0.99596E 00 0.10385E 01 0.99596E 00 0.99596E 00 0.99596E 00
 13 0.12631579E 01    0.72961E-08    0.00000 0.10001E 01 0.99560E 00 0.10385E 01 0.99559E 00 0.99559E 00 0.99559E 00
 14 0.13684211E 01    0.72957E-08    0.00000 0.10001E 01 0.99523E 00 0.10385E 01 0.99522E 00 0.99522E 00 0.99522E 00
 15 0.14736842E 01    0.72953E-08    0.00000 0.10001E 01 0.99486E 00 0.10385E 01 0.99485E 00 0.99485E 00 0.99485E 00
 16 0.15789474E 01    0.72949E-08    0.00000 0.10001E 01 0.99449E 00 0.10385E 01 0.99448E 00 0.99448E 00 0.99449E 00
 17 0.16842105E 01    0.72945E-08    0.00000 0.10001E 01 0.99412E 00 0.10385E 01 0.99412E 00 0.99412E 00 0.99412E 00
 18 0.17894737E 01    0.72941E-08    0.00000 0.10001E 01 0.99375E 00 0.10385E 01 0.99375E 00 0.99375E 00 0.99375E 00
 19 0.18947368E 01    0.72937E-08    0.00000 0.10001E 01 0.99339E 00 0.10385E 01 0.99338E 00 0.99338E 00 0.99338E 00
 20 0.20000000E 01    0.72933E-08    0.00000 0.10001E 01 0.99301E 00 0.10385E 01 0.99300E 00 0.99300E 00 0.99300E 00
0 START -- TOTAL MASS = 0.1985675364E 01  TOTAL ENERGY = 0.1561919368E 01
 CURRENT -- TOTAL MASS = 0.1985745486E 01  TOTAL ENERGY = 0.1561995107E 01
 PERCENT DIFFERENCE -- IN MASS = 0.00353        IN ENERGY = 0.00485


0** TIME STEP NO.   2 CPTIME=  0.00 MIN. TPHYS= 0.11250E-01 DT= 0.62500E-02 VISC STAB= 0.152E-06 IDTADJ=  1
 ** SSTEST= 0.8492E-02 AT LX= 19 LY=  1 LZ= 20 RATIO=   8.492   MAX. CHANGE -- (IEQ)=
 ** ( 1)=-0.1488E-03   ( 3)=-0.8492E-02   ( 4)= 0.2076E-03  (
0** REAVG= 0.115E 01 RESMAX= 0.234E 01 LX= 10 LY=  1 LZ= 19
 IEQ= 1 RESAVG= 0.338E-01 RESEQ=-0.276E 00 LX= 19LY=  1 LZ=  2 IEQ= 3 RESAVG= 0.115E 01 RESEQ= 0.234E 01 LX= 10 LY=  1 LZ= 19
 IEQ= 4 RESAVG= 0.214E 00 RESEQ= 0.490E 00 LX= 11LY=  1 LZ=  8 IEQ=
 CONV - AMP(L,M,H),RMS CONV . CONV+DIFF, AMP(L,M,H),RMS DIFF
 MAX  -0.10000E 26  -0.10000E 26  -0.10000E 26  -0.10000E 26  -0.10000E 26  -0.10000E 26  -0.10000E 26  -0.10000E 26
 MIN   0.10000E 26   0.10000E 26   0.10000E 26   0.10000E 26   0.10000E 26   0.10000E 26   0.10000E 26   0.10000E 26
 DTISAV, JCBN= 0.16000E 03 0.14858E-03
              AN          VAR(N)       DVAR(N+1)   A/DT*DVAR    L1*DVAR      L2*DVAR      L3*DVAR       DVAR(*)     A/DT*DVAR*  L1*(DV-DV*

 EQ 1 VAR 1  0.96563E 00 0.16050E-04 0.26463E-05 0.40886E-03-0.10728E-03    0.00000 0.20670E-03
 EQ 1 VAR 3     0.00000 0.30816E 00-0.16803E-02    0.00000 0.98377E-01    0.00000 0.27092E-08
 EQ 1 VAR 4  0.16050E-04 0.96563E 00-0.41388E-04-0.10628E-06-0.10103E 00    0.00000 0.10908E-08
 EQ= 1 A,L1,L2,L3,RES,SPLIT= 0.40875E-03-0.27628E-02    0.00000 0.20670E-03 0.69159E-02 0.39510E-02

 EQ 3 VAR 1     0.00000 0.16050E-04 0.26463E-05    0.00000-0.21964E-04    0.00000-0.15863E-08
 EQ 3 VAR 3  0.96563E 00 0.30816E 00-0.16803E-02-0.25961E 00-0.12789E-01    0.00000 0.11040E-03
 EQ 3 VAR 4  0.30816E 00 0.96563E 00-0.41388E-04-0.20406E-02 0.30974E 00    0.00000 0.86745E-03
 EQ= 3 A,L1,L2,L3,RES,SPLIT=-0.26165E 00-0.12811E-01    0.00000 0.97785E-03-0.25002E 00-0.20716E-03

 EQ 4 VAR 1     0.00000 0.16050E-04 0.26463E-05    0.00000-0.38187E-02    0.00000    0.00000
 EQ 4 VAR 3     0.00000 0.30816E 00-0.16803E-02    0.00000    0.00000    0.00000 0.16345E-03
 EQ 4 VAR 4  0.10000E 01 0.96563E 00-0.41388E-04-0.66221E-02 0.48782E-07    0.00000 0.13337E-03
 EQ= 4 A,L1,L2,L3,RES,SPLIT=-0.66221E-02-0.38186E-02    0.00000 0.29682E-03-0.35361E-02-0.43586E-03
```

```
 LZ      Z           U-VEL       V-VEL     W-VEL    DENSITY     ENTHALPY    PBOT        PTOP        DP
  1   0.00000000   0.29271E-07  0.00000 0.99995E 00 0.10000E 01 0.10385E 01 0.10007E 01 0.10007E 01 0.10000E 01
  2 0.10526316E 00 0.25935E-07  0.00000 0.10001E 01 0.99966E 00 0.10385E 01 0.99998E 00 0.99998E 00 0.99965E 00
  3 0.21052632E 00 0.22598E-07  0.00000 0.10001E 01 0.99930E 00 0.10385E 01 0.99927E 00 0.99927E 00 0.99929E 00
  4 0.31578947E 00 0.22126E-07  0.00000 0.10001E 01 0.99893E 00 0.10385E 01 0.99890E 00 0.99890E 00 0.99892E 00
  5 0.42105263E 00 0.22074E-07  0.00000 0.10001E 01 0.99857E 00 0.10385E 01 0.99853E 00 0.99853E 00 0.99855E 00
  6 0.52631579E 00 0.22068E-07  0.00000 0.10001E 01 0.99820E 00 0.10385E 01 0.99816E 00 0.99816E 00 0.99819E 00
  7 0.63157895E 00 0.22065E-07  0.00000 0.10001E 01 0.99783E 00 0.10385E 01 0.99779E 00 0.99779E 00 0.99782E 00
  8 0.73684211E 00 0.22064E-07  0.00000 0.10001E 01 0.99746E 00 0.10385E 01 0.99743E 00 0.99743E 00 0.99745E 00
  9 0.84210526E 00 0.22062E-07  0.00000 0.10001E 01 0.99709E 00 0.10385E 01 0.99706E 00 0.99706E 00 0.99708E 00
 10 0.94736842E 00 0.22060E-07  0.00000 0.10001E 01 0.99672E 00 0.10385E 01 0.99669E 00 0.99669E 00 0.99671E 00
 11 0.10526316E 01 0.22058E-07  0.00000 0.10001E 01 0.99636E 00 0.10385E 01 0.99632E 00 0.99632E 00 0.99634E 00
 12 0.11578947E 01 0.22056E-07  0.00000 0.10001E 01 0.99599E 00 0.10385E 01 0.99595E 00 0.99595E 00 0.99598E 00
 13 0.12631579E 01 0.22054E-07  0.00000 0.10001E 01 0.99562E 00 0.10385E 01 0.99558E 00 0.99558E 00 0.99561E 00
 14 0.13684211E 01 0.22052E-07  0.00000 0.10001E 01 0.99525E 00 0.10385E 01 0.99521E 00 0.99521E 00 0.99524E 00
 15 0.14736842E 01 0.22050E-07  0.00000 0.10001E 01 0.99488E 00 0.10385E 01 0.99485E 00 0.99485E 00 0.99487E 00
 16 0.15789474E 01 0.22048E-07  0.00000 0.10001E 01 0.99451E 00 0.10385E 01 0.99448E 00 0.99448E 00 0.99450E 00
 17 0.16842105E 01 0.22046E-07  0.00000 0.10001E 01 0.99414E 00 0.10385E 01 0.99411E 00 0.99411E 00 0.99413E 00
 18 0.17894737E 01 0.22012E-07  0.00000 0.10001E 01 0.99378E 00 0.10385E 01 0.99374E 00 0.99374E 00 0.99376E 00
 19 0.18947368E 01 0.21864E-07  0.00000 0.10002E 01 0.99341E 00 0.10385E 01 0.99337E 00 0.99337E 00 0.99340E 00
 20 0.20000000E 01 0.21716E-07  0.00000 0.10002E 01 0.99301E 00 0.10385E 01 0.99300E 00 0.99300E 00 0.99300E 00
0 START -- TOTAL MASS = 0.1985675364E 01  TOTAL ENERGY = 0.1561919368E 01
  CURRENT -- TOTAL MASS = 0.1985792633E 01  TOTAL ENERGY = 0.1562046685E 01
  PERCENT DIFFERENCE -- IN MASS = 0.00591         IN ENERGY = 0.00815


0** TIME STEP NO.  3 CPTIME=  0.00 MIN. TPHYS= 0.19063E-01 DT= 0.78125E-02 VISC STAB= 0.190E-06 IDTADJ= 1
 ** SSTEST= 0.8751E-02 AT LX= 19 LY= 1 LZ= 20 RATIO=  8.751   MAX. CHANGE -- (IEQ)=
 ** ( 1)=-0.1734E-03  ( 3)=-0.8751E-02  ( 4)= 0.1399E-03  (
0** REAVG= 0.114E 01 RESMAX= 0.238E 01 LX= 11 LY= 1 LZ= 19
  IEQ= 1 RESAVG= 0.508E-01 RESEQ=-0.353E 00 LX= 19LY= 1 LZ= 2 IEQ= 3 RESAVG= 0.114E 01 RESEQ= 0.238E 01 LX= 11 LY= 1 LZ= 19
  IEQ= 4 RESAVG= 0.211E 00 RESEQ= 0.491E 00 LX= 11LY= 1 LZ= 8 IEQ=
  CONV - AMP(L,M,H),RMS CONV . CONV+DIFF, AMP(L,N,H),RMS DIFF
  MAX  -0.10000E 26  -0.10000E 26  -0.10000E 26  -0.10000E 26  -0.10000E 26  -0.10000E 26  -0.10000E 26  -0.10000E 26
  MIN   0.10000E 26   0.10000E 26   0.10000E 26   0.10000E 26   0.10000E 26   0.10000E 26   0.10000E 26   0.10000E 26
  DTISAV, JCBN= 0.12800E 03 0.14858E-03
              AN        VAR(N)     DVAR(N+1)   A/DT*DVAR  L1*DVAR    L2*DVAR    L3*DVAR    DVAR(*)    A/DT*DVAR*  L1*(DV-DV*

 EQ 1 VAR 1  0.96559E 00 0.18696E-04-0.24903E-05-0.30779E-03-0.15818E-03    0.00000 0.15764E-03
 EQ 1 VAR 3     0.00000 0.30648E 00-0.21801E-02    0.00000 0.93197E-01    0.00000-0.72624E-06
 EQ 1 VAR 4  0.18696E-04 0.96559E 00-0.55478E-04-0.13276E-06-0.88454E-01    0.00000-0.29576E-08
 EQ= 1 A,L1,L2,L3,RES,SPLIT=-0.30793E-03 0.45850E-03    0.00000 0.15691E-03 0.43471E-02 0.93970E-02

 EQ 3 VAR 1     0.00000 0.18696E-04-0.24903E-05    0.00000 0.20160E-02    0.00000-0.65138E-08
 EQ 3 VAR 3  0.96559E 00 0.30648E 00-0.21801E-02-0.26945E 00-0.11496E-01    0.00000 0.25752E-03
 EQ 3 VAR 4  0.30648E 00 0.96559E 00-0.55478E-04-0.21763E-02 0.61880E-07    0.00000 0.41900E-03
 EQ= 3 A,L1,L2,L3,RES,SPLIT=-0.27163E 00-0.94796E-02    0.00000 0.67651E-03-0.26300E 00-0.17521E-03

 EQ 4 VAR 1     0.00000 0.18696E-04-0.24903E-05    0.00000-0.90953E-03    0.00000    0.00000
 EQ 4 VAR 3     0.00000 0.30648E 00-0.21801E-02    0.00000    0.00000    0.00000 0.36994E-03
 EQ 4 VAR 4  0.10000E 01 0.96559E 00-0.55478E-04-0.71012E-02 0.52699E-06    0.00000 0.68938E-04
 EQ= 4 A,L1,L2,L3,RES,SPLIT=-0.71012E-02-0.90901E-03    0.00000 0.43888E-03-0.70663E-02-0.43523E-03

 LZ      Z           U-VEL       V-VEL     W-VEL    DENSITY     ENTHALPY    PBOT        PTOP        DP
  1   0.00000000   0.53564E-07  0.00000 0.99996E 00 0.10000E 01 0.10385E 01 0.10008E 01 0.10008E 01 0.10000E 01
  2 0.10526316E 00 0.43330E-07  0.00000 0.10002E 01 0.99968E 00 0.10385E 01 0.10001E 01 0.10001E 01 0.99966E 00
  3 0.21052632E 00 0.33097E-07  0.00000 0.10002E 01 0.99933E 00 0.10385E 01 0.99926E 00 0.99926E 00 0.99931E 00
  4 0.31578947E 00 0.31073E-07  0.00000 0.10002E 01 0.99896E 00 0.10385E 01 0.99889E 00 0.99889E 00 0.99894E 00
  5 0.42105263E 00 0.30766E-07  0.00000 0.10002E 01 0.99859E 00 0.10385E 01 0.99852E 00 0.99852E 00 0.99857E 00
  6 0.52631579E 00 0.30720E-07  0.00000 0.10002E 01 0.99822E 00 0.10385E 01 0.99816E 00 0.99816E 00 0.99821E 00
  7 0.63157895E 00 0.30709E-07  0.00000 0.10002E 01 0.99786E 00 0.10385E 01 0.99779E 00 0.99779E 00 0.99784E 00
  8 0.73684211E 00 0.30703E-07  0.00000 0.10002E 01 0.99749E 00 0.10385E 01 0.99742E 00 0.99742E 00 0.99747E 00
  9 0.84210526E 00 0.30696E-07  0.00000 0.10002E 01 0.99712E 00 0.10385E 01 0.99705E 00 0.99705E 00 0.99710E 00
 10 0.94736842E 00 0.30690E-07  0.00000 0.10002E 01 0.99675E 00 0.10385E 01 0.99668E 00 0.99668E 00 0.99673E 00
 11 0.10526316E 01 0.30684E-07  0.00000 0.10002E 01 0.99638E 00 0.10385E 01 0.99631E 00 0.99631E 00 0.99636E 00
 12 0.11578947E 01 0.30678E-07  0.00000 0.10002E 01 0.99601E 00 0.10385E 01 0.99594E 00 0.99594E 00 0.99600E 00
 13 0.12631579E 01 0.30672E-07  0.00000 0.10002E 01 0.99565E 00 0.10385E 01 0.99558E 00 0.99558E 00 0.99563E 00
 14 0.13684211E 01 0.30666E-07  0.00000 0.10002E 01 0.99528E 00 0.10385E 01 0.99521E 00 0.99521E 00 0.99526E 00
 15 0.14736842E 01 0.30659E-07  0.00000 0.10002E 01 0.99491E 00 0.10385E 01 0.99484E 00 0.99484E 00 0.99489E 00
 16 0.15789474E 01 0.30653E-07  0.00000 0.10002E 01 0.99454E 00 0.10385E 01 0.99447E 00 0.99447E 00 0.99452E 00
 17 0.16842105E 01 0.30644E-07  0.00000 0.10002E 01 0.99417E 00 0.10385E 01 0.99410E 00 0.99410E 00 0.99415E 00
 18 0.17894737E 01 0.30540E-07  0.00000 0.10002E 01 0.99380E 00 0.10385E 01 0.99373E 00 0.99373E 00 0.99378E 00
 19 0.18947368E 01 0.30240E-07  0.00000 0.10003E 01 0.99343E 00 0.10385E 01 0.99337E 00 0.99337E 00 0.99341E 00
 20 0.20000000E 01 0.29940E-07  0.00000 0.10003E 01 0.99302E 00 0.10385E 01 0.99300E 00 0.99300E 00 0.99300E 00
OCP TIME PER STEP =    0.000
OCP TIMES - TOTAL, ADI, MATRIX =   0.000    0.000    0.000
```

ORESTART DUMP STARTED AT TIME STEP   3   UNIT NO. = 20   RESTART NO. = 1

ORESTART DUMP COMPLETED AT TIME STEP   3   UNIT NO. = 10   RESTART NO. = 1

1***** FINAL FLOW FIELD *****
ORESULTS AT TSTEP NO.   3   TIME =0.190625E-01

0***** U-VL   *****

```
OLZ=      1        2        3        4        5        6        7        8        9       10
  Z=      0.0000000.105263E 000.210526E 000.315789E 000.421053E 000.526316E 000.631579E 000.736842E 000.842105E 000.947368E 00

 20     0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000
 19  -0.61999E-04-0.12505E-04 0.36989E-04 0.34609E-04 0.34499E-04 0.34478E-04 0.34478E-04 0.34481E-04 0.34483E-04 0.34486E-04
 18  -0.27445E-03-0.14533E-03-0.16206E-04-0.13017E-04-0.12623E-04-0.12611E-04-0.12612E-04-0.12614E-04-0.12616E-04-0.12613E-04
 17  -0.20709E-03-0.99025E-04 0.90438E-05 0.10705E-04 0.10906E-04 0.10899E-04 0.10895E-04 0.10890E-04 0.10886E-04 0.10881E-04
 16  -0.30997E-03-0.17396E-03-0.37942E-04-0.30149E-04-0.29349E-04-0.29296E-04-0.29293E-04-0.29296E-04-0.29299E-04-0.29301E-04
 15  -0.85028E-04-0.42141E-04 0.74595E-06 0.36568E-05 0.39797E-05 0.40004E-05 0.39979E-05 0.39932E-05 0.39883E-05 0.39834E-05
 14   0.99070E-04 0.78991E-04 0.58911E-04 0.55717E-04 0.55341E-04 0.55299E-04 0.55294E-04 0.55292E-04 0.55291E-04 0.55290E-04
 13   0.17071E-04 0.14258E-04 0.11446E-04 0.11044E-04 0.11002E-04 0.10999E-04 0.11000E-04 0.11001E-04 0.11002E-04 0.11003E-04
 12  -0.13856E-04-0.10595E-04-0.73346E-05-0.66975E-05-0.66055E-05-0.65935E-05-0.65916E-05-0.65908E-05-0.65902E-05-0.65896E-05
 11  -0.53564E-07-0.43330E-07-0.33097E-07-0.31073E-07-0.30766E-07-0.30720E-07-0.30709E-07-0.30703E-07-0.30696E-07-0.30690E-07
 10   0.53564E-07 0.43330E-07 0.33097E-07 0.31073E-07 0.30766E-07 0.30720E-07 0.30709E-07 0.30703E-07 0.30699E-07 0.30690E-07
  9   0.13856E-04 0.10595E-04 0.73346E-05 0.66975E-05 0.66055E-05 0.65935E-05 0.65916E-05 0.65902E-05 0.65902E-05 0.65896E-05
  8  -0.17071E-04-0.14258E-04-0.11446E-04-0.11044E-04-0.11002E-04-0.10999E-04-0.11000E-04-0.11001E-04-0.11002E-04-0.11003E-04
  7  -0.99070E-04-0.78991E-04-0.58911E-04-0.55717E-04-0.55341E-04-0.55299E-04-0.55294E-04-0.55292E-04-0.55291E-04-0.55290E-04
  6   0.85028E-04 0.42141E-04-0.74595E-06-0.36568E-05-0.39797E-05-0.40004E-05-0.39979E-05-0.39932E-05-0.39383E-05-0.39834E-05
  5   0.30997E-03 0.17396E-03 0.37942E-04 0.30149E-04 0.29349E-04 0.29296E-04 0.29293E-04 0.29296E-04 0.29299E-04 0.29301E-04
  4   0.20709E-03 0.99025E-04-0.90438E-05-0.10705E-04-0.10906E-04-0.10899E-04-0.10895E-04-0.10890E-04-0.10886E-04-0.10881E-04
  3   0.27445E-03 0.14533E-03 0.16206E-04 0.13017E-04 0.12623E-04 0.12611E-04 0.12612E-04 0.12614E-04 0.12616E-04 0.12613E-04
  2   0.61999E-04 0.12505E-04-0.36989E-04-0.34609E-04-0.34499E-04-0.34478E-04-0.34478E-04-0.34481E-04-0.34483E-04-0.34486E-04
  1     0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000

OLZ=     11       12       13       14       15       16       17       18       19       20
  Z= 0.105263E 010.115789E 010.126316E 010.136842E 010.147368E 010.157895E 010.168421E 010.178947E 010.189474E 010.200000E 01

 20     0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000
 19   0.34488E-04 0.34491E-04 0.34493E-04 0.34496E-04 0.34498E-04 0.34500E-04 0.34502E-04 0.34363E-04 0.34115E-04 0.33867E-04
 18  -0.12620E-04-0.12622E-04-0.12624E-04-0.12626E-04-0.12628E-04-0.12630E-04-0.12632E-04-0.12626E-04-0.12622E-04-0.12618E-04
 17   0.10877E-04 0.10873E-04 0.10868E-04 0.10864E-04 0.10859E-04 0.10854E-04 0.10848E-04 0.10729E-04 0.10493E-04 0.10266E-04
 16  -0.29304E-04-0.29307E-04-0.29310E-04-0.29312E-04-0.29315E-04-0.29318E-04-0.29320E-04-0.29263E-04-0.29212E-04-0.29162E-04
 15   0.39785E-05 0.39735E-05 0.39686E-05 0.39637E-05 0.39588E-05 0.39537E-05 0.39432E-05 0.39205E-05 0.38344E-05 0.37483E-05
 14   0.55289E-04 0.55287E-04 0.55286E-04 0.55285E-04 0.55284E-04 0.55281E-04 0.55274E-04 0.55018E-04 0.54226E-04 0.53434E-04
 13   0.11005E-04 0.11006E-04 0.11007E-04 0.11009E-04 0.11010E-04 0.11011E-04 0.11011E-04 0.10960E-04 0.10782E-04 0.10604E-04
 12  -0.65890E-05-0.65884E-05-0.65879E-05-0.65873E-05-0.65867E-05-0.65859E-05-0.65847E-05-0.65545E-05-0.64594E-05-0.63644E-05
 11  -0.30684E-07-0.30678E-07-0.30672E-07-0.30666E-07-0.30659E-07-0.30653E-07-0.30644E-07-0.30540E-07-0.30240E-07-0.29940E-07
 10   0.30684E-07 0.30678E-07 0.30672E-07 0.30666E-07 0.30659E-07 0.30653E-07 0.30644E-07 0.30540E-07 0.30240E-07 0.29940E-07
  9   0.65890E-05 0.65884E-05 0.65879E-05 0.65873E-05 0.65867E-05 0.65859E-05 0.65847E-05 0.65545E-05 0.64594E-05 0.63644E-05
  8  -0.11005E-04-0.11006E-04-0.11007E-04-0.11009E-04-0.11010E-04-0.11011E-04-0.11011E-04-0.10960E-04-0.10782E-04-0.10604E-04
  7  -0.55289E-04-0.55287E-04-0.55286E-04-0.55285E-04-0.55284E-04-0.55281E-04-0.55274E-04-0.55018E-04-0.54226E-04-0.53434E-04
  6  -0.39785E-05-0.39735E-05-0.39686E-05-0.39637E-05-0.39538E-05-0.39537E-05-0.39482E-05-0.39205E-05-0.38344E-05-0.37483E-05
  5   0.29304E-04 0.29307E-04 0.29310E-04 0.29312E-04 0.29315E-04 0.29318E-04 0.29320E-04 0.29263E-04 0.29212E-04 0.29162E-04
  4  -0.10877E-04-0.10873E-04-0.10868E-04-0.10864E-04-0.10859E-04-0.10854E-04-0.10848E-04-0.10729E-04-0.10493E-04-0.10266E-04
  3   0.12620E-04 0.12622E-04 0.12624E-04 0.12626E-04 0.12628E-04 0.12630E-04 0.12632E-04 0.12626E-04 0.12622E-04 0.12618E-04
  2  -0.34488E-04-0.34491E-04-0.34493E-04-0.34496E-04-0.34498E-04-0.34500E-04-0.34502E-04-0.34363E-04-0.34115E-04-0.33867E-04
  1     0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000
```
ORESULTS AT TSTEP NO.   3   TIME =0.190625E-01

0***** W-VL   *****

```
OLZ=      1        2        3        4        5        6        7        8        9       10
  Z=      0.0000000.105263E 000.210526E 000.315789E 000.421053E 000.526316E 000.631579E 000.736842E 000.842105E 000.947368E 00

 20     0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000
 19   0.12988E 00 0.10517E 00 0.10490E 00 0.10481E 00 0.10480E 00 0.10479E 00 0.10479E 00 0.10478E 00 0.10477E 00 0.10476E 00
 18   0.30943E 00 0.30441E 00 0.30430E 00 0.30426E 00 0.30426E 00 0.30426E 00 0.30426E 00 0.30425E 00 0.30425E 00 0.30425E 00
 17   0.40971E 00 0.40957E 00 0.40959E 00 0.40959E 00 0.40959E 00 0.40959E 00 0.40959E 00 0.40959E 00 0.40959E 00 0.40959E 00
 16   0.48185E 00 0.48272E 00 0.48278E 00 0.48278E 00 0.48278E 00 0.48278E 00 0.48278E 00 0.48278E 00 0.48278E 00 0.48278E 00
 15   0.56345E 00 0.56499E 00 0.56510E 00 0.56511E 00 0.56512E 00 0.56512E 00 0.56512E 00 0.56512E 00 0.56512E 00 0.56512E 00
 14   0.70807E 00 0.70874E 00 0.70881E 00 0.70882E 00 0.70882E 00 0.70882E 00 0.70882E 00 0.70882E 00 0.70882E 00 0.70882E 00
 13   0.97078E 00 0.97051E 00 0.97047E 00 0.97047E 00 0.97047E 00 0.97047E 00 0.97047E 00 0.97047E 00 0.97047E 00 0.97047E 00
 12   0.99995E 00 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01
 11   0.99996E 00 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01
 10   0.99996E 00 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01
  9   0.99995E 00 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01 0.10002E 01
```

```
        8     0.97078E 00  0.97051E 00  0.97047E 00  0.97047E 00  0.97047E 00  0.97047E 00  0.97047E 00  0.97047E 00  0.97047E 00  0.97047E 00
        7     0.70807E 00  0.70874E 00  0.70881E 00  0.70882E 00  0.70882E 00  0.70882E 00  0.70882E 00  0.70882E 00  0.70882E 00  0.70882E 00
        6     0.56345E 00  0.56499E 00  0.56510E 00  0.56511E 00  0.56512E 00  0.56512E 00  0.56512E 00  0.56512E 00  0.56512E 00  0.56512E 00
        5     0.48185E 00  0.48272E 00  0.48278E 00  0.48278E 00  0.48278E 00  0.48278E 00  0.48278E 00  0.48278E 00  0.48278E 00  0.48278E 00
        4     0.40971E 00  0.40957E 00  0.40959E 00  0.40959E 00  0.40959E 00  0.40959E 00  0.40959E 00  0.40959E 00  0.40959E 00  0.40959E 00
        3     0.30943E 00  0.30441E 00  0.30430E 00  0.30426E 00  0.30426E 00  0.30426E 00  0.30426E 00  0.30425E 00  0.30425E 00  0.30425E 00
        2     0.12988E 00  0.10517E 00  0.10490E 00  0.10481E 00  0.10480E 00  0.10479E 00  0.10479E 00  0.10478E 00  0.10477E 00  0.10476E 00
        1      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000

0LZ=         11           12           13           14           15           16           17           18           19           20
  Z=   0.105263 010.115789 010.126316 010.136842 010.147368 010.157895 010.168421 010.178947 010.189474 010.200000 01

       20      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
       19     0.10475E 00  0.10474E 00  0.10473E 00  0.10473E 00  0.10472E 00  0.10471E 00  0.10470E 00  0.10469E 00  0.10468E 00  0.10468E 00
       18     0.30425E 00  0.30424E 00  0.30424E 00  0.30424E 00  0.30424E 00  0.30424E 00  0.30423E 00  0.30423E 00  0.30423E 00  0.30423E 00
       17     0.40959E 00  0.40959E 00  0.40959E 00  0.40959E 00  0.40959E 00  0.40959E 00  0.40959E 00  0.40959E 00  0.40959E 00  0.40959E 00
       16     0.48278E 00  0.48278E 00  0.48278E 00  0.48278E 00  0.48278E 00  0.48278E 00  0.48278E 00  0.48278E 00  0.48279E 00  0.48279E 00
       15     0.56512E 00  0.56512E 00  0.56512E 00  0.56512E 00  0.56512E 00  0.56512E 00  0.56512E 00  0.56512E 00  0.56511E 00  0.56511E 00
       14     0.70882E 00  0.70882E 00  0.70882E 00  0.70882E 00  0.70882E 00  0.70882E 00  0.70882E 00  0.70882E 00  0.70882E 00  0.70883E 00
       13     0.97047E 00  0.97047E 00  0.97047E 00  0.97047E 00  0.97047E 00  0.97047E 00  0.97047E 00  0.97047E 00  0.97049E 00  0.97051E 00
       12     0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10003E 01  0.10003E 01
       11     0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10003E 01  0.10003E 01
       10     0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10003E 01  0.10003E 01
        9     0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10002E 01  0.10003E 01  0.10003E 01
        8     0.97047E 00  0.97047E 00  0.97047E 00  0.97047E 00  0.97047E 00  0.97047E 00  0.97047E 00  0.97047E 00  0.97049E 00  0.97051E 00
        7     0.70882E 00  0.70882E 00  0.70882E 00  0.70882E 00  0.70882E 00  0.70882E 00  0.70882E 00  0.70882E 00  0.70882E 00  0.70883E 00
        6     0.56512E 00  0.56512E 00  0.56512E 00  0.56512E 00  0.56512E 00  0.56512E 00  0.56512E 00  0.56512E 00  0.56511E 00  0.56511E 00
        5     0.48278E 00  0.48278E 00  0.48278E 00  0.48278E 00  0.48278E 00  0.48278E 00  0.48278E 00  0.48278E 00  0.48279E 00  0.48279E 00
        4     0.40959E 00  0.40959E 00  0.40959E 00  0.40959E 00  0.40959E 00  0.40959E 00  0.40959E 00  0.40959E 00  0.40959E 00  0.40959E 00
        3     0.30425E 00  0.30424E 00  0.30424E 00  0.30424E 00  0.30424E 00  0.30424E 00  0.30423E 00  0.30423E 00  0.30423E 00  0.30423E 00
        2     0.10475E 00  0.10474E 00  0.10473E 00  0.10473E 00  0.10472E 00  0.10471E 00  0.10470E 00  0.10469E 00  0.10468E 00  0.10468E 00
        1      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
0RESULTS AT TSTEP NO.    3     TIME =0.190625E-01

0*****  DENS          *****

0LZ=          1            2            3            4            5            6            7            8            9           10
  Z=    0.0000000.105263 000.210526 000.315789 000.421053 000.526316 000.631579 000.736842 000.842105 000.947368 00

       20     0.96373E 00  0.96298E 00  0.96222E 00  0.96186E 00  0.96151E 00  0.96115E 00  0.96080E 00  0.96044E 00  0.96009E 00  0.95973E 00
       19     0.96418E 00  0.96329E 00  0.96260E 00  0.96225E 00  0.96189E 00  0.96153E 00  0.96118E 00  0.96082E 00  0.96047E 00  0.96011E 00
       18     0.96655E 00  0.96599E 00  0.96553E 00  0.96517E 00  0.96482E 00  0.96446E 00  0.96411E 00  0.96375E 00  0.96339E 00  0.96304E 00
       17     0.96899E 00  0.96861E 00  0.96823E 00  0.96788E 00  0.96752E 00  0.96717E 00  0.96681E 00  0.96645E 00  0.96610E 00  0.96574E 00
       16     0.97129E 00  0.97096E 00  0.97060E 00  0.97025E 00  0.96989E 00  0.96953E 00  0.96918E 00  0.96882E 00  0.96846E 00  0.96810E 00
       15     0.97429E 00  0.97404E 00  0.97374E 00  0.97338E 00  0.97303E 00  0.97267E 00  0.97231E 00  0.97195E 00  0.97159E 00  0.97123E 00
       14     0.98110E 00  0.98081E 00  0.98048E 00  0.98013E 00  0.97977E 00  0.97941E 00  0.97904E 00  0.97868E 00  0.97832E 00  0.97796E 00
       13     0.99791E 00  0.99751E 00  0.99712E 00  0.99675E 00  0.99638E 00  0.99601E 00  0.99565E 00  0.99528E 00  0.99491E 00  0.99454E 00
       12     0.10000E 01  0.99968E 00  0.99933E 00  0.99896E 00  0.99859E 00  0.99322E 00  0.99786E 00  0.99749E 00  0.99712E 00  0.99675E 00
       11     0.10000E 01  0.99968E 00  0.99933E 00  0.99896E 00  0.99859E 00  0.99822E 00  0.99786E 00  0.99749E 00  0.99712E 00  0.99675E 00
       10     0.10000E 01  0.99968E 00  0.99933E 00  0.99896E 00  0.99859E 00  0.99822E 00  0.99786E 00  0.99749E 00  0.99712E 00  0.99675E 00
        9     0.10000E 01  0.99968E 00  0.99933E 00  0.99896E 00  0.99859E 00  0.99822E 00  0.99786E 00  0.99749E 00  0.99712E 00  0.99675E 00
        8     0.99791E 00  0.99751E 00  0.99712E 00  0.99675E 00  0.99638E 00  0.99601E 00  0.99565E 00  0.99528E 00  0.99491E 00  0.99454E 00
        7     0.98110E 00  0.98081E 00  0.98048E 00  0.98013E 00  0.97977E 00  0.97941E 00  0.97904E 00  0.97868E 00  0.97832E 00  0.97796E 00
        6     0.97429E 00  0.97404E 00  0.97374E 00  0.97338E 00  0.97303E 00  0.97267E 00  0.97231E 00  0.97195E 00  0.97159E 00  0.97123E 00
        5     0.97129E 00  0.97096E 00  0.97060E 00  0.97025E 00  0.96989E 00  0.96953E 00  0.96918E 00  0.96882E 00  0.96846E 00  0.96810E 00
        4     0.96899E 00  0.96861E 00  0.96823E 00  0.96788E 00  0.96752E 00  0.96717E 00  0.96681E 00  0.96645E 00  0.96610E 00  0.96574E 00
        3     0.96655E 00  0.96599E 00  0.96553E 00  0.96517E 00  0.96482E 00  0.96446E 00  0.96411E 00  0.96375E 00  0.96339E 00  0.96304E 00
        2     0.96418E 00  0.96329E 00  0.96260E 00  0.96225E 00  0.96189E 00  0.96153E 00  0.96118E 00  0.96082E 00  0.96047E 00  0.96011E 00
        1     0.96373E 00  0.96298E 00  0.96222E 00  0.96186E 00  0.96151E 00  0.96115E 00  0.96080E 00  0.96044E 00  0.96009E 00  0.95973E 00

0LZ=         11           12           13           14           15           16           17           18           19           20
  Z=   0.105263 010.115789 010.126316 010.136842 010.147368 010.157895 010.168421 010.178947 010.189474 010.200000 01

       20     0.95938E 00  0.95902E 00  0.95867E 00  0.95831E 00  0.95796E 00  0.95760E 00  0.95725E 00  0.95689E 00  0.95654E 00  0.95619E 00
       19     0.95976E 00  0.95940E 00  0.95905E 00  0.95870E 00  0.95834E 00  0.95799E 00  0.95763E 00  0.95728E 00  0.95692E 00  0.95657E 00
       18     0.96268E 00  0.96233E 00  0.96197E 00  0.96161E 00  0.96126E 00  0.96090E 00  0.96055E 00  0.96019E 00  0.95983E 00  0.95948E 00
       17     0.96538E 00  0.96502E 00  0.96467E 00  0.96431E 00  0.96395E 00  0.96360E 00  0.96324E 00  0.96288E 00  0.96253E 00  0.96217E 00
       16     0.96774E 00  0.96739E 00  0.96703E 00  0.96667E 00  0.96631E 00  0.96596E 00  0.96560E 00  0.96524E 00  0.96488E 00  0.96452E 00
       15     0.97087E 00  0.97051E 00  0.97015E 00  0.96980E 00  0.96944E 00  0.96908E 00  0.96872E 00  0.96836E 00  0.96800E 00  0.96764E 00
       14     0.97760E 00  0.97724E 00  0.97688E 00  0.97651E 00  0.97615E 00  0.97579E 00  0.97543E 00  0.97507E 00  0.97471E 00  0.97433E 00
       13     0.99418E 00  0.99381E 00  0.99344E 00  0.99307E 00  0.99271E 00  0.99234E 00  0.99197E 00  0.99160E 00  0.99123E 00  0.99078E 00
       12     0.99638E 00  0.99601E 00  0.99565E 00  0.99528E 00  0.99491E 00  0.99454E 00  0.99417E 00  0.99380E 00  0.99343E 00  0.99302E 00
       11     0.99638E 00  0.99601E 00  0.99565E 00  0.99528E 00  0.99491E 00  0.99454E 00  0.99417E 00  0.99380E 00  0.99343E 00  0.99302E 00
       10     0.99638E 00  0.99601E 00  0.99565E 00  0.99528E 00  0.99491E 00  0.99454E 00  0.99417E 00  0.99380E 00  0.99343E 00  0.99302E 00
        9     0.99638E 00  0.99601E 00  0.99565E 00  0.99528E 00  0.99491E 00  0.99454E 00  0.99417E 00  0.99380E 00  0.99343E 00  0.99302E 00
        8     0.99418E 00  0.99381E 00  0.99344E 00  0.99307E 00  0.99271E 00  0.99234E 00  0.99197E 00  0.99160E 00  0.99123E 00  0.99078E 00
        7     0.97760E 00  0.97724E 00  0.97688E 00  0.97651E 00  0.97615E 00  0.97579E 00  0.97543E 00  0.97507E 00  0.97471E 00  0.97433E 00
        6     0.97087E 00  0.97051E 00  0.97015E 00  0.96980E 00  0.96944E 00  0.96908E 00  0.96872E 00  0.96836E 00  0.96800E 00  0.96764E 00
        5     0.96774E 00  0.96739E 00  0.96703E 00  0.96667E 00  0.96631E 00  0.96596E 00  0.96560E 00  0.96524E 00  0.96488E 00  0.96452E 00
        4     0.96538E 00  0.96502E 00  0.96467E 00  0.96431E 00  0.96395E 00  0.96360E 00  0.96324E 00  0.96288E 00  0.96253E 00  0.96217E 00
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   3    0.96268E 00 0.96233E 00 0.96197E 00 0.96161E 00 0.96126E 00 0.96090E 00 0.96055E 00 0.96019E 00 0.95983E 00 0.95948E 00
   2    0.95976E 00 0.95940E 00 0.95905E 00 0.95870E 00 0.95834E 00 0.95799E 00 0.95763E 00 0.95728E 00 0.95692E 00 0.95657E 00
   1    0.95938E 00 0.95902E 00 0.95867E 00 0.95831E 00 0.95796E 00 0.95760E 00 0.95725E 00 0.95689E 00 0.95654E 00 0.95619E 00
0RESULTS AT TSTEP NO.    3    TIME =0.190625E-01

0***** PRES         *****

0LZ=      1           2           3           4           5           6           7           8           9          10
  Z=    0.0000000.105263E 000.210526E 000.315789E 000.421053E 000.526316E 000.631579E 000.736842E 000.842105E 000.947368E 00

  20    0.10008E 01 0.10001E 01 0.99926E 00 0.99889E 00 0.99852E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
  19    0.10007E 01 0.99997E 00 0.99926E 00 0.99889E 00 0.99852E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
  18    0.10002E 01 0.99973E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
  17    0.10000E 01 0.99965E 00 0.99926E 00 0.99889E 00 0.99852E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
  16    0.10000E 01 0.99963E 00 0.99926E 00 0.99890E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99706E 00 0.99669E 00
  15    0.99989E 00 0.99957E 00 0.99925E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
  14    0.99993E 00 0.99960E 00 0.99927E 00 0.99890E 00 0.99854E 00 0.99817E 00 0.99780E 00 0.99743E 00 0.99706E 00 0.99669E 00
  13    0.10001E 01 0.99974E 00 0.99935E 00 0.99898E 00 0.99861E 00 0.99825E 00 0.99788E 00 0.99751E 00 0.99714E 00 0.99677E 00
  12    0.10000E 01 0.99966E 00 0.99931E 00 0.99894E 00 0.99857E 00 0.99821E 00 0.99784E 00 0.99747E 00 0.99710E 00 0.99673E 00
  11    0.10000E 01 0.99966E 00 0.99931E 00 0.99894E 00 0.99857E 00 0.99821E 00 0.99784E 00 0.99747E 00 0.99710E 00 0.99673E 00
  10    0.10000E 01 0.99966E 00 0.99931E 00 0.99894E 00 0.99857E 00 0.99821E 00 0.99784E 00 0.99747E 00 0.99710E 00 0.99673E 00
   9    0.10000E 01 0.99966E 00 0.99931E 00 0.99894E 00 0.99857E 00 0.99821E 00 0.99784E 00 0.99747E 00 0.99710E 00 0.99673E 00
   8    0.10001E 01 0.99974E 00 0.99935E 00 0.99898E 00 0.99861E 00 0.99825E 00 0.99788E 00 0.99751E 00 0.99714E 00 0.99677E 00
   7    0.99993E 00 0.99960E 00 0.99927E 00 0.99890E 00 0.99854E 00 0.99817E 00 0.99780E 00 0.99743E 00 0.99706E 00 0.99669E 00
   6    0.99989E 00 0.99957E 00 0.99925E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
   5    0.10000E 01 0.99963E 00 0.99926E 00 0.99890E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99706E 00 0.99669E 00
   4    0.10000E 01 0.99965E 00 0.99926E 00 0.99889E 00 0.99852E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
   3    0.10002E 01 0.99973E 00 0.99926E 00 0.99889E 00 0.99853E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
   2    0.10007E 01 0.99997E 00 0.99926E 00 0.99889E 00 0.99852E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00
   1    0.10008E 01 0.10001E 01 0.99926E 00 0.99889E 00 0.99852E 00 0.99816E 00 0.99779E 00 0.99742E 00 0.99705E 00 0.99668E 00


0LZ=     11          12          13          14          15          16          17          18          19          20
  Z=    0.105263E 010.115789E 010.126316E 010.136842E 010.147368E 010.157895E 010.168421E 010.178947E 010.189474E 010.200000E 01

  20    0.99631E 00 0.99594E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99410E 00 0.99373E 00 0.99337E 00 0.99300E 00
  19    0.99631E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99410E 00 0.99373E 00 0.99337E 00 0.99300E 00
  18    0.99631E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99410E 00 0.99374E 00 0.99337E 00 0.99300E 00
  17    0.99631E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99410E 00 0.99374E 00 0.99337E 00 0.99300E 00
  16    0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99485E 00 0.99448E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
  15    0.99631E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99410E 00 0.99374E 00 0.99337E 00 0.99300E 00
  14    0.99633E 00 0.99596E 00 0.99559E 00 0.99522E 00 0.99485E 00 0.99448E 00 0.99412E 00 0.99375E 00 0.99338E 00 0.99300E 00
  13    0.99640E 00 0.99603E 00 0.99567E 00 0.99530E 00 0.99493E 00 0.99456E 00 0.99419E 00 0.99382E 00 0.99345E 00 0.99300E 00
  12    0.99636E 00 0.99600E 00 0.99563E 00 0.99526E 00 0.99489E 00 0.99452E 00 0.99415E 00 0.99378E 00 0.99341E 00 0.99300E 00
  11    0.99636E 00 0.99600E 00 0.99563E 00 0.99526E 00 0.99489E 00 0.99452E 00 0.99415E 00 0.99378E 00 0.99341E 00 0.99300E 00
  10    0.99636E 00 0.99600E 00 0.99563E 00 0.99526E 00 0.99489E 00 0.99452E 00 0.99415E 00 0.99378E 00 0.99341E 00 0.99300E 00
   9    0.99636E 00 0.99600E 00 0.99563E 00 0.99526E 00 0.99489E 00 0.99452E 00 0.99415E 00 0.99378E 00 0.99341E 00 0.99300E 00
   8    0.99640E 00 0.99603E 00 0.99567E 00 0.99530E 00 0.99493E 00 0.99456E 00 0.99419E 00 0.99382E 00 0.99345E 00 0.99300E 00
   7    0.99633E 00 0.99596E 00 0.99559E 00 0.99522E 00 0.99485E 00 0.99448E 00 0.99412E 00 0.99375E 00 0.99338E 00 0.99300E 00
   6    0.99631E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99410E 00 0.99374E 00 0.99337E 00 0.99300E 00
   5    0.99632E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99485E 00 0.99448E 00 0.99411E 00 0.99374E 00 0.99337E 00 0.99300E 00
   4    0.99631E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99410E 00 0.99374E 00 0.99337E 00 0.99300E 00
   3    0.99631E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99410E 00 0.99374E 00 0.99337E 00 0.99300E 00
   2    0.99631E 00 0.99595E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99410E 00 0.99373E 00 0.99337E 00 0.99300E 00
   1    0.99631E 00 0.99594E 00 0.99558E 00 0.99521E 00 0.99484E 00 0.99447E 00 0.99410E 00 0.99373E 00 0.99337E 00 0.99300E 00
0RESULTS AT TSTEP NO.    3    TIME =0.190625E-01

0***** TEMP         *****

0LZ=      1           2           3           4           5           6           7           8           9          10
  Z=    0.0000000.105263E 000.210526E 000.315789E 000.421053E 000.526316E 000.631579E 000.736842E 000.842105E 000.947368E 00

  20    0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01
  19    0.10379E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01
  18    0.10348E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01
  17    0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01
  16    0.10296E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01
  15    0.10263E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01
  14    0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01
  13    0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01
  12    0.10000E 01 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00
  11    0.10000E 01 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00
  10    0.10000E 01 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00
   9    0.10000E 01 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00
   8    0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01
   7    0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01
   6    0.10263E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01
   5    0.10296E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01
   4    0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01
   3    0.10348E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01
   2    0.10379E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01
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    1    0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10335E 01

OLZ=        11          12          13          14          15          16          17          18          19          20
  Z=  0.105263E 010.115789E 010.126316E 010.136842E 010.147368E 010.157895E 010.168421E 010.178947E 010.189474E 010.200000E 01

20  0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01
19  0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01
18  0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01
17  0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01
16  0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01
15  0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01
14  0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01
13  0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01
12  0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00
11  0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00
10  0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00
 9  0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00 0.99998E 00
 8  0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01 0.10022E 01
 7  0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01 0.10192E 01
 6  0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01 0.10262E 01
 5  0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01 0.10295E 01
 4  0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01 0.10320E 01
 3  0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01 0.10349E 01
 2  0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01 0.10381E 01
 1  0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01 0.10385E 01
ORESULTS AT TSTEP NO.    3    TIME =0.190625E-01

O***** VISC          *****

OLZ=         1           2           3           4           5           6           7           8           9          10
  Z=  0.0000000.105263E 000.210526E 000.315789E 000.421053E 000.526316E 000.631579E 000.736842E 000.842105E 000.947368E 00

20  0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01
19  0.10825E 01 0.10813E 01 0.10812E 01 0.10812E 01 0.10812E 01 0.10811E 01 0.10811E 01 0.10811E 01 0.10811E 01 0.10810E 01
18  0.16935E 01 0.18089E 01 0.18097E 01 0.18095E 01 0.18091E 01 0.18086E 01 0.18081E 01 0.18076E 01 0.18071E 01 0.18066E 01
17  0.31123E 01 0.32409E 01 0.32433E 01 0.32427E 01 0.32413E 01 0.32399E 01 0.32384E 01 0.32370E 01 0.32356E 01 0.32342E 01
16  0.10248E 02 0.10417E 02 0.10421E 02 0.10418E 02 0.10413E 02 0.10407E 02 0.10401E 02 0.10395E 02 0.10389E 02 0.10383E 02
15  0.69477E 02 0.69373E 02 0.69348E 02 0.69313E 02 0.69280E 02 0.69242E 02 0.69204E 02 0.69166E 02 0.69127E 02 0.69089E 02
14  0.31576E 03 0.31416E 03 0.31392E 03 0.31376E 03 0.31362E 03 0.31348E 03 0.31334E 03 0.31320E 03 0.31306E 03 0.31292E 03
13  0.18182E 03 0.18165E 03 0.18158E 03 0.18151E 03 0.18143E 03 0.18136E 03 0.18129E 03 0.18121E 03 0.18114E 03 0.18106E 03
12  0.12361E 02 0.12564E 02 0.12588E 02 0.12585E 02 0.12585E 02 0.12581E 02 0.12577E 02 0.12572E 02 0.12568E 02 0.12564E 02
11  0.15651E 01 0.12303E 01 0.10422E 01 0.10192E 01 0.10169E 01 0.10168E 01 0.10168E 01 0.10168E 01 0.10168E 01 0.10168E 01
10  0.15651E 01 0.12303E 01 0.10422E 01 0.10192E 01 0.10169E 01 0.10168E 01 0.10168E 01 0.10168E 01 0.10168E 01 0.10168E 01
 9  0.12361E 02 0.12564E 02 0.12588E 02 0.12585E 02 0.12585E 02 0.12581E 02 0.12577E 02 0.12572E 02 0.12568E 02 0.12564E 02
 8  0.18182E 03 0.18165E 03 0.18158E 03 0.18151E 03 0.18143E 03 0.18136E 03 0.18129E 03 0.18121E 03 0.18114E 03 0.18106E 03
 7  0.31576E 03 0.31416E 03 0.31392E 03 0.31376E 03 0.31362E 03 0.31348E 03 0.31334E 03 0.31320E 03 0.31306E 03 0.31292E 03
 6  0.69477E 02 0.69373E 02 0.69348E 02 0.69318E 02 0.69280E 02 0.69242E 02 0.69204E 02 0.69166E 02 0.69127E 02 0.69089E 02
 5  0.10248E 02 0.10417E 02 0.10421E 02 0.10418E 02 0.10413E 02 0.10407E 02 0.10401E 02 0.10395E 02 0.10389E 02 0.10383E 02
 4  0.31123E 01 0.32409E 01 0.32433E 01 0.32427E 01 0.32413E 01 0.32399E 01 0.32384E 01 0.32370E 01 0.32356E 01 0.32342E 01
 3  0.16935E 01 0.18089E 01 0.18095E 01 0.18095E 01 0.18091E 01 0.18086E 01 0.18081E 01 0.18076E 01 0.18071E 01 0.18066E 01
 2  0.10825E 01 0.10813E 01 0.10812E 01 0.10812E 01 0.10812E 01 0.10811E 01 0.10811E 01 0.10811E 01 0.10811E 01 0.10810E 01
 1  0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01

OLZ=        11          12          13          14          15          16          17          18          19          20
  Z=  0.105263E 010.115789E 010.126316E 010.136842E 010.147368E 010.157895E 010.168421E 010.178947E 010.189474E 010.200000E 01

20  0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01
19  0.10810E 01 0.10810E 01 0.10810E 01 0.10809E 01 0.10809E 01 0.10809E 01 0.10808E 01 0.10808E 01 0.10808E 01 0.10808E 01
18  0.18061E 01 0.18057E 01 0.18052E 01 0.18047E 01 0.18042E 01 0.18037E 01 0.18032E 01 0.18027E 01 0.18023E 01 0.18018E 01
17  0.32327E 01 0.32313E 01 0.32299E 01 0.32285E 01 0.32271E 01 0.32256E 01 0.32242E 01 0.32228E 01 0.32214E 01 0.32200E 01
16  0.10377E 02 0.10371E 02 0.10365E 02 0.10359E 02 0.10353E 02 0.10347E 02 0.10341E 02 0.10336E 02 0.10329E 02 0.10323E 02
15  0.69051E 02 0.69013E 02 0.68975E 02 0.68937E 02 0.68899E 02 0.68860E 02 0.68822E 02 0.68784E 02 0.68746E 02 0.68708E 02
14  0.31277E 03 0.31263E 03 0.31249E 03 0.31235E 03 0.31221E 03 0.31207E 03 0.31193E 03 0.31179E 03 0.31167E 03 0.31154E 03
13  0.18099E 03 0.18092E 03 0.18084E 03 0.18077E 03 0.18069E 03 0.18062E 03 0.18055E 03 0.18047E 03 0.18040E 03 0.18031E 03
12  0.12559E 02 0.12555E 02 0.12551E 02 0.12546E 02 0.12542E 02 0.12538E 02 0.12534E 02 0.12529E 02 0.12521E 02 0.12512E 02
11  0.10168E 01 0.10168E 01 0.10168E 01 0.10168E 01 0.10168E 01 0.10168E 01 0.10168E 01 0.10231E 01 0.10315E 01 0.10315E 01
10  0.10168E 01 0.10168E 01 0.10168E 01 0.10168E 01 0.10168E 01 0.10168E 01 0.10168E 01 0.10231E 01 0.10315E 01 0.10315E 01
 9  0.12559E 02 0.12555E 02 0.12551E 02 0.12546E 02 0.12542E 02 0.12538E 02 0.12534E 02 0.12529E 02 0.12521E 02 0.12512E 02
 8  0.18099E 03 0.18092E 03 0.18084E 03 0.18077E 03 0.18069E 03 0.18062E 03 0.18055E 03 0.18047E 03 0.18040E 03 0.18031E 03
 7  0.31277E 03 0.31263E 03 0.31249E 03 0.31235E 03 0.31221E 03 0.31207E 03 0.31193E 03 0.31179E 03 0.31167E 03 0.31154E 03
 6  0.69051E 02 0.69013E 02 0.68975E 02 0.68937E 02 0.68899E 02 0.68860E 02 0.68822E 02 0.68784E 02 0.68746E 02 0.68708E 02
 5  0.10377E 02 0.10371E 02 0.10365E 02 0.10359E 02 0.10353E 02 0.10347E 02 0.10341E 02 0.10336E 02 0.10329E 02 0.10323E 02
 4  0.32327E 01 0.32313E 01 0.32299E 01 0.32285E 01 0.32271E 01 0.32256E 01 0.32242E 01 0.32228E 01 0.32214E 01 0.32200E 01
 3  0.18061E 01 0.18057E 01 0.18052E 01 0.18047E 01 0.18042E 01 0.18037E 01 0.18032E 01 0.18027E 01 0.18023E 01 0.18018E 01
 2  0.10810E 01 0.10810E 01 0.10810E 01 0.10809E 01 0.10809E 01 0.10809E 01 0.10808E 01 0.10808E 01 0.10808E 01 0.10808E 01
 1  0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01 0.10431E 01
ORESULTS AT TSTEP NO.    3    TIME =0.190625E-01

O***** MIXL          *****
```

```
OLZ=       1         2         3         4         5         6         7         8         9         10
  Z=    0.0000000.105263E 000.210526E 000.315789E 000.421053E 000.526316E 000.631579E 000.736842E 000.842105E 000.947368E 00

 20      0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000
 19    0.18276E-04 0.18126E-04 0.18117E-04 0.18113E-04 0.18110E-04 0.18107E-04 0.18103E-04 0.18100E-04 0.18097E-04 0.18094E-04
 18    0.12048E-03 0.12487E-03 0.12489E-03 0.12489E-03 0.12487E-03 0.12485E-03 0.12483E-03 0.12482E-03 0.12480E-03 0.12478E-03
 17    0.41989E-03 0.42558E-03 0.42568E-03 0.42566E-03 0.42560E-03 0.42554E-03 0.42548E-03 0.42541E-03 0.42535E-03 0.42529E-03
 16    0.14387E-02 0.14443E-02 0.14444E-02 0.14443E-02 0.14441E-02 0.14439E-02 0.14437E-02 0.14435E-02 0.14434E-02 0.14432E-02
 15    0.49169E-02 0.49160E-02 0.49157E-02 0.49153E-02 0.49149E-02 0.49144E-02 0.49139E-02 0.49135E-02 0.49130E-02 0.49125E-02
 14    0.11686E-01 0.11684E-01 0.11683E-01 0.11683E-01 0.11683E-01 0.11682E-01 0.11682E-01 0.11681E-01 0.11681E-01 0.11680E-01
 13    0.14829E-01 0.14836E-01 0.14837E-01 0.14837E-01 0.14836E-01 0.14836E-01 0.14836E-01 0.14835E-01 0.14835E-01 0.14835E-01
 12    0.15467E-01 0.15477E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01
 11    0.15467E-01 0.15477E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01
 10    0.15467E-01 0.15477E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01
  9    0.15467E-01 0.15477E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01
  8    0.14829E-01 0.14836E-01 0.14837E-01 0.14837E-01 0.14836E-01 0.14836E-01 0.14836E-01 0.14835E-01 0.14835E-01 0.14835E-01
  7    0.11686E-01 0.11684E-01 0.11684E-01 0.11683E-01 0.11683E-01 0.11682E-01 0.11682E-01 0.11681E-01 0.11681E-01 0.11680E-01
  6    0.49169E-02 0.49160E-02 0.49157E-02 0.49153E-02 0.49149E-02 0.49144E-02 0.49139E-02 0.49135E-02 0.49130E-02 0.49125E-02
  5    0.14387E-02 0.14443E-02 0.14444E-02 0.14443E-02 0.14441E-02 0.14439E-02 0.14437E-02 0.14435E-02 0.14434E-02 0.14432E-02
  4    0.41989E-03 0.42558E-03 0.42568E-03 0.42566E-03 0.42560E-03 0.42554E-03 0.42548E-03 0.42541E-03 0.42535E-03 0.42529E-03
  3    0.12048E-03 0.12487E-03 0.12489E-03 0.12489E-03 0.12487E-03 0.12485E-03 0.12483E-03 0.12482E-03 0.12480E-03 0.12478E-03
  2    0.18276E-04 0.18126E-04 0.18117E-04 0.18113E-04 0.18110E-04 0.18107E-04 0.18103E-04 0.18100E-04 0.18097E-04 0.18094E-04
  1      0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000

OLZ=      11        12        13        14        15        16        17        18        19        20
  Z=   0.105263E 010.115789E 010.126316E 010.136842E 010.147368E 010.157895E 010.168421E 010.178947E 010.189474E 010.200000E 01

 20      0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000
 19    0.18091E-04 0.18087E-04 0.18084E-04 0.18081E-04 0.18078E-04 0.18075E-04 0.18072E-04 0.18066E-04 0.18065E-04 0.18062E-04
 18    0.12476E-03 0.12474E-03 0.12472E-03 0.12471E-03 0.12469E-03 0.12467E-03 0.12465E-03 0.12463E-03 0.12462E-03 0.12460E-03
 17    0.42523E-03 0.42517E-03 0.42511E-03 0.42505E-03 0.42498E-03 0.42492E-03 0.42486E-03 0.42480E-03 0.42474E-03 0.42468E-03
 16    0.14430E-02 0.14428E-02 0.14426E-02 0.14424E-02 0.14422E-02 0.14420E-02 0.14418E-02 0.14416E-02 0.14414E-02 0.14412E-02
 15    0.49121E-02 0.49116E-02 0.49111E-02 0.49106E-02 0.49102E-02 0.49097E-02 0.49092E-02 0.49083E-02 0.49083E-02 0.49078E-02
 14    0.11680E-01 0.11680E-01 0.11679E-01 0.11679E-01 0.11678E-01 0.11678E-01 0.11677E-01 0.11677E-01 0.11676E-01 0.11676E-01
 13    0.14835E-01 0.14834E-01 0.14834E-01 0.14834E-01 0.14833E-01 0.14833E-01 0.14833E-01 0.14832E-01 0.14832E-01 0.14831E-01
 12    0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01
 11    0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01
 10    0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01
  9    0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01 0.15478E-01
  8    0.14835E-01 0.14834E-01 0.14834E-01 0.14834E-01 0.14833E-01 0.14833E-01 0.14833E-01 0.14832E-01 0.14832E-01 0.14831E-01
  7    0.11680E-01 0.11680E-01 0.11679E-01 0.11679E-01 0.11678E-01 0.11678E-01 0.11677E-01 0.11677E-01 0.11676E-01 0.11676E-01
  6    0.49121E-02 0.49116E-02 0.49111E-02 0.49106E-02 0.49102E-02 0.49097E-02 0.49092E-02 0.49083E-02 0.49083E-02 0.49078E-02
  5    0.14430E-02 0.14428E-02 0.14426E-02 0.14424E-02 0.14422E-02 0.14420E-02 0.14418E-02 0.14415E-02 0.14414E-02 0.14412E-02
  4    0.42523E-03 0.42517E-03 0.42511E-03 0.42505E-03 0.42499E-03 0.42492E-03 0.42486E-03 0.42480E-03 0.42474E-03 0.42468E-03
  3    0.12476E-03 0.12474E-03 0.12472E-03 0.12471E-03 0.12469E-03 0.12467E-03 0.12465E-03 0.12463E-03 0.12462E-03 0.12460E-03
  2    0.18091E-04 0.18087E-04 0.18084E-04 0.18081E-04 0.18078E-04 0.18075E-04 0.18072E-04 0.18068E-04 0.18065E-04 0.18062E-04
  1      0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000
ORESULTS AT TSTEP NO.    3    TIME =0.190625E-01

0***** MACH        *****

OLZ=       1         2         3         4         5         6         7         8         9         10
  Z=    0.0000000.105263E 000.210526E 000.315789E 000.421053E 000.526316E 000.631579E 000.736842E 000.842105E 000.947368E 00

 20      0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000
 19    0.55942E-01 0.45294E-01 0.45177E-01 0.45140E-01 0.45136E-01 0.45133E-01 0.45129E-01 0.45125E-01 0.45121E-01 0.45118E-01
 18    0.13347E 00 0.13130E 00 0.13125E 00 0.13124E 00 0.13124E 00 0.13124E 00 0.13124E 00 0.13124E 00 0.13123E 00 0.13123E 00
 17    0.17697E 00 0.17691E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00
 16    0.20838E 00 0.20876E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00
 15    0.24406E 00 0.24473E 00 0.24478E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00
 14    0.30776E 00 0.30806E 00 0.30809E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00
 13    0.42551E 00 0.42539E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00
 12    0.43878E 00 0.43890E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00
 11    0.43878E 00 0.43890E 00 0.43891E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00
 10    0.43878E 00 0.43890E 00 0.43891E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00
  9    0.43878E 00 0.43890E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00
  8    0.42551E 00 0.42539E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00
  7    0.30776E 00 0.30806E 00 0.30809E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00
  6    0.24406E 00 0.24473E 00 0.24478E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00
  5    0.20838E 00 0.20876E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00
  4    0.17697E 00 0.17691E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00
  3    0.13347E 00 0.13130E 00 0.13125E 00 0.13124E 00 0.13124E 00 0.13124E 00 0.13124E 00 0.13124E 00 0.13123E 00 0.13123E 00
  2    0.55942E-01 0.45294E-01 0.45177E-01 0.45140E-01 0.45136E-01 0.45133E-01 0.45129E-01 0.45125E-01 0.45121E-01 0.45118E-01
  1      0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000

OLZ=      11        12        13        14        15        16        17        18        19        20
  Z=   0.105263E 010.115789E 010.126316E 010.136842E 010.147368E 010.157895E 010.168421E 010.178947E 010.189474E 010.200000E 01

 20      0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000    0.00000
 19    0.45114E-01 0.45110E-01 0.45107E-01 0.45103E-01 0.45099E-01 0.45096E-01 0.45092E-01 0.45088E-01 0.45085E-01 0.45081E-01
```

```
18   0.13123E 00 0.13123E 00 0.13123E 00 0.13123E 00 0.13123E 00 0.13123E  ! 0.13123E 00 0.13123E 00 0.13123E 00 0.13122E 00
17   0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00
16   0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00
15   0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00
14   0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00
13   0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42538E 00 0.42539E 00
12   0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43892E 00 0.43893E 00
11   0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43893E 00
10   0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43892E 00 0.43893E 00
 9   0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43891E 00 0.43892E 00 0.43893E 00
 8   0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42537E 00 0.42538E 00 0.42539E 00
 7   0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00 0.30810E 00
 6   0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00 0.24479E 00
 5   0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00 0.20879E 00
 4   0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00 0.17692E 00
 3   0.13123E 00 0.13123E 00 0.13123E 00 0.13123E 00 0.13123E 00 0.13123E 00 0.13123E 00 0.13123E 00 0.13123E 00 0.13122E 00
 2·  0.45114E-01 0.45110E-01 0.45107E-01 0.45103E-01 0.45099E-01 0.45096E-01 0.45092E-01 0.45088E-01 0.45085E-01 0.45081E-01
 1    0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     0.00000
ORESULTS AT TSTEP NO.    3    TIME =0.190625E-01

O***** TIME PLOTS *****

O***** DIR1 PLOTS *****

O***** DIR3 PLOTS *****
    CHCHW400     TERMINATED: STOP
    RELEASE FT
    ERASE R9
    0512         CANCELLED: R9 UNKNOWN.
    ERASE R19
    0512         CANCELLED: R19 UNKNOWN.
    ERASE MINT
    ERASE PROCM
    ERASE M
    0512         CANCELLED: M UNKNOWN.
    ERASE SC01
    ERASE SC10
    ERASE SC20
    LOGOFF
    R007         LOGOFF AT 15:31 ON 11/10/82 - CPU TIME=     0.68 MINUTES.
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		6. Performing Organization Code
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15. Supplementary Notes

16. Abstract

The multi-dimensional ensemble-averaged compressible time-dependent Navier-Stokes equations in conjunction with mixing length turbulence model and shock capturing technique have been used to study the terminal shock type of flows in various flight regimes occurring in a diffuser/inlet model. The numerical scheme for solving the governing equations is based on a linearized block implicit approach and the following high Reynolds number calculations have been carried out: (1) 2-D, steady, subsonic; (2) 2-D, steady, transonic with normal shock; (3) 2-D, steady, supersonic with terminal shock; (4) 2-D, transient process of shock development and (5) 3-D, steady, transonic with normal shock. The numerical results obtained for the 2-D and 3-D transonic shocked flows have been compared with corresponding experimental data; the calculated wall static pressure distributions agree well with the measured data.

17. Key Words (Suggested by Author(s)) Numerical solutions; Navier-Stokes equations; Compressible turbulent 2-D and 3-D flows; Terminal shocks; Inlets and diffusers	18. Distribution Statement Unclassified - unlimited STAR Category 34

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